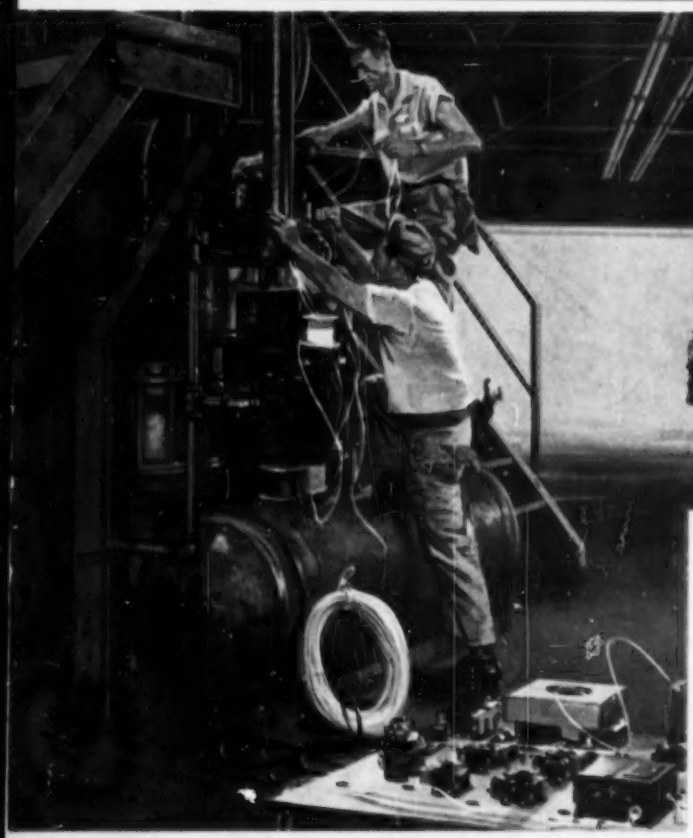
the Petroleum Engineer

FOR MANAGEMENT

INTEGRATED EDITION OF THE PETROLEUM ENGINEER

4 VIEWS OF GAS LEGISLATION

1. Federal Power Commissioner
2. Pipeline Company President
3. Gas Utility President
4. Independent Producer



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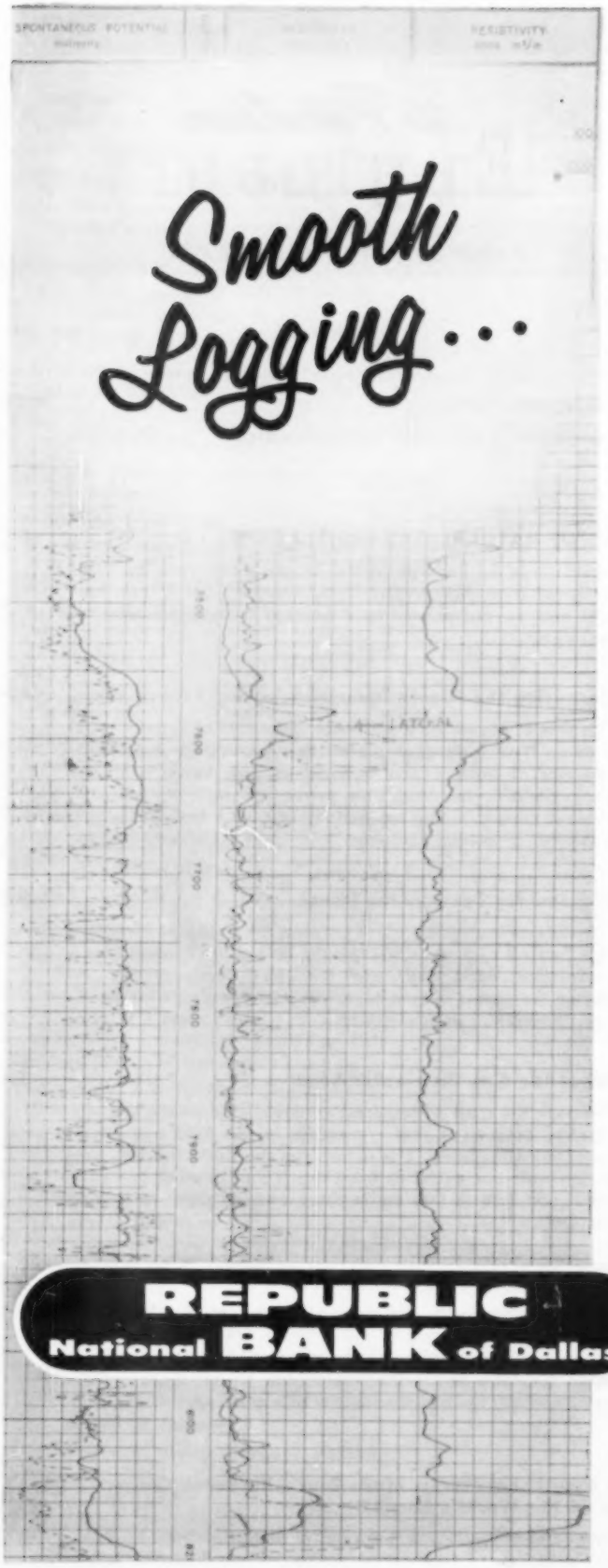

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A gentleman is consistent, not changeless. — *Confucius*

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"Passage of legislation which removes the producer's facilities from Federal regulation will greatly relieve the Federal Power Commission work load, and this relief, undoubtedly, will shorten the period of time necessary to process pipeline certificate applications and rate cases." — *Joseph J. Hedrick*

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"Perhaps the most widespread misconception of the gas distributing business is that companies in this field operate as protected monopolies. This is far from the truth. The only protection from our exclusive franchise is that another gas company cannot come into our territory and lay pipes to provide gas service." — *John E. Heyke*

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Utility-type regulation "in many instances sets a price of gas in excess of what you can sell it for. In other fields the price thus determined is far below the price you have contracted to sell it for, and below the reasonable market price . . . This method wholly ignores the sanctity of a contract." — *Arch H. Rowan*

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THE HUMAN EQUATION

IN the natural gas panel at the TIPRO annual meeting, a Federal Power Commissioner said, "No one has learned how to apply a slide rule or a log table to solve the human equation." So we can only take a human estimate of the results of open and vigorous discussion of four phases of natural gas by the panel members.

Viewpoints of FPC, of the long lines, of the distributor, and of the producer were explained simply and stoutly defended. Brooklyn Union Gas Company's president said that much dissention among the branches of the natural gas industry could have been avoided if they had met and learned more about each other's problems 10 years ago. They may not agree now on many points, but understanding takes some of the sting out of disagreement. TIPRO served the industry well in getting the four sides together.

We think the arguments of each so important for the industry to know, that we are publishing them in full in this issue. (Page E-3.)

Natural gas competes on the wholesale level with manufactured gas and with coal and oil. It competes at retail with several other energies. Producers are fighting Federal regulation to keep in a competitive supply position at wholesale; distributors feel some regulation is needed to assure themselves of a competitive price position. The transmission man, in the middle, wants to keep both happy—the producer he buys from and the distributor he sells to.

A minority of distributors, legislators, and some political groups believe that natural gas should be regulated. Among them are those with the theory that regulation is the preferred state for all business and industry.

Business and industry, however, are made up of people and you can't apply the slide rule of government regulation to solve the human equation.

The trouble with the human equation—or its wonderful saving grace—is that it cannot be successfully regulated. You can put a ceiling on human effort by law but you cannot put a base under it. You can stop it but you have a hard time starting it up and making it go in a narrow stream of endeavor.

In essence, this was what the producer on the panel was saying when he protested a utility type method for determining price of natural gas. He was saying that human effort must have room to grow if gas reserves are to grow.

Solution to the four-viewpoint problem must be hammered out by the same immeasurable factor—the human equation.

Ernestine Adams

Congrats and $25 to A. V. McIvor, 1255 Wabash St., Pasadena, Calif., for this quip.

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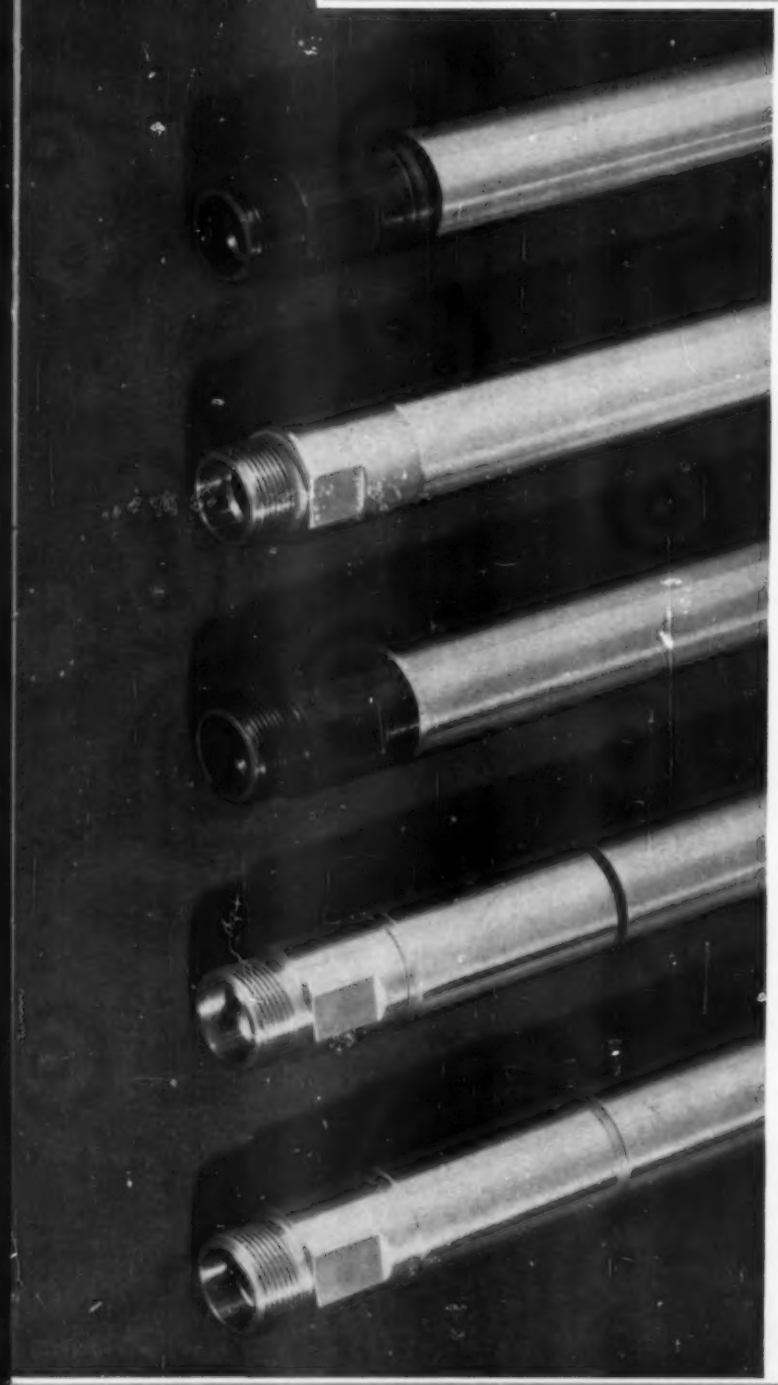
Which "Oilwell" plunger will do your pumping job best?



That depends on well conditions. But you can be sure that one of these "Oilwell" Subsurface Pump Plungers has already proved itself under the conditions you are likely to meet.

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SUPER-HARD The surface of this one-piece nickel-iron Super-Hard Plunger is induction hardened to make its naturally excellent wearing properties even more superior. Nickel content and its microstructure combine to give outstanding corrosion resistance in sour corrosive wells.

SUPER-HARD STEEL A seamless alloy steel tube is induction hardened to improve the surface of the Super-Hard Steel Plunger, while retaining its tough core. Recommended for abrasive service in non-corrosive wells.

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Petroleum Profile

THERE is but one living man still actively engaged in the search for oil throughout the world who pioneered in the Appalachian area almost 70 years ago when wells of "post-hole" depth (800 to 1500 ft) supplied all of America's demand for petroleum products.

That man is the Great Wildcatter,* Michael Late Benedum of Pittsburgh, who is reputed to have discovered more oil than any other individual in history. Now nearing his 88th birthday (July 16), this last remaining link with the romantic and boisterous days of the industry's infancy is still carrying on new breath-taking exploratory projects. Individually and through companies which he controls, "Uncle Mike," as he is known, is drilling in every oil producing area of the United States and has only recently initiated large scale undertakings in South and Central American and Africa on a total of more than three million acres.

In his office daily from nine to five, including Saturdays, ("I didn't find oil and make money working only 40 hours a week.") Mike Benedum is familiar with the last detail of every project in which he has an interest. He also finds time, personally to direct the distribution of a large portion of his fortune. ("I do not regard this money as belonging to me. Providence has seen fit to make me the trustee of it, and it is my obligation to use it for the benefit of others.")

How well "Uncle Mike" has discharged this obligation can be measured to some extent in terms of the 700-odd students in 26 colleges in the Pittsburgh area who are beneficiaries of Benedum scholarships and student loan funds. Dozens of churches, hospitals and other like institutions in the same section of the country receive financial support from him.

The small West Virginia community of Bridgeport, where the Great Wildcatter was born and reared, has been the object of much of the Benedum philanthropy. The population and wealth of that town has quadrupled in the last 10 years, during which period its most beloved and distinguished native son built a two-million dollar church; a community center, with library, auditorium, dining room, club rooms, swimming pool, ice skating rink, and playgrounds at about the same cost; and restored and beautified the town's old cemeteries at a total cost of about half a million dollars.

MICHAEL LATE BENEDUM

The Great Wildcatter

Instead of the flamboyant character most people associate with oil wildcatting, especially those who were active in the early days of wild and wooly boom towns, Mr. Benedum is a quiet, shy and soft spoken individual. Despite his advanced years, he still walks as erectly as a West Point cadet. Widowed since 1951, and childless since 1918, when his only son died while serving his country in the First World War, the Great Wildcatter lives alone on an eight-acre estate in the heart of Pittsburgh's residential East End.

There business associates and friends are frequent dinner guests, later joining "Uncle Mike" before one of the three television screens in his 23-room mansion. It is entirely in keeping with his vision and pioneering spirit that his favorite programs are of the Superman and Science Fiction type.

"I know that you boys think I am in my dotage," he says to associates, "but do you realize that the things they show you in these plays are not half as fantastic as what we actually have today would have been to my father and mother."

"Uncle Mike" may have something there. It is a fact that he has "had something" through the years as he risked his money and endeavors on the future he envisioned, but which most of his contemporaries regarded as pure fantasy. Some thought he was suffering from the mid-summer heat of Louisiana when, at the time of his discovery of the Caddo field in 1907, he predicted the day would come when America would consume three million barrels of oil every day. When that day arrived, he went out on another limb with the prophecy that this demand would treble in three decades.

Now, as the Great Wildcatter looks at the space men on his television, he says that many now in the oil business will live to see the day when domestic demand reaches 15 million barrels a day.

Funny thing is that no one laughs at his predictions any more.

*The book, "The Great Wildcatter," by Sam Mallison is not only the story of Mike Benedum but an excellent history of the petroleum industry.

For Shell Oil Co....

SIX CAT* ELECTRIC SETS POWER THE FIRST DIESEL-ELECTRIC, TRAILER-MOUNTED DRILL RIG

Shell Oil Co. has put a revolutionary new drilling rig to work in the Julesburg basin of Nebraska and northeast Colorado. It's the first rig to combine the flexibility of diesel-electric power and the portability of trailer-mounted components. The basic drilling unit—power, drawworks, rig—is mounted on three trailers.

Power is provided by six Caterpillar Electric Sets, mounted on a specially built trailer. Four D337 and two D318 Electric Sets produce a total of 720 KW for the entire operation. Because the power is delivered through 100-foot lengths of cable rather than through a mechanical drive, the power trailer can be located anywhere in the drilling site, instead of being accurately aligned. As a result of this and other time-saving operations, the rig can be set up and taken down at least one day faster than the conventional rig it replaces. Based on an average of 30 moves annually, the new rig will be able to drill one month more each year.

The four Cat D337 Electric Sets are coupled to General Electric flange-mounted, single-bearing generators to provide power for the Ideco rig. Each of the D318s is coupled to a 25 KW DC and a 30 KW, 3-phase, 60-cycle AC generator supplying DC excitation for the prime generators and AC power to air compressor, washdown pump, shale shaker, blowout preventer closing unit, rig lights and drillers' doghouse lights. One of the above D318s provides 100 per cent standby capacity.

Diesel-electric rigs—first used offshore—now are spreading to land applications. In this development, as in others, men in oil patches throughout the world look to their Caterpillar Dealers for the engines and electric sets which have proved their dependability and high production for a quarter century.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

CATERPILLAR*

*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.

A QUARTER CENTURY OF DIESEL LEADERSHIP

THE CONFERENCE TABLE

A gentleman is consistent, not changeless —CONFUCIUS

Inflation in Advertising

Two companies who supply the petroleum industry have used inflation as subjects of advertising they've carried in various publications.

Republic Steel uses this approach:

"Prices go higher in a time of shortage when demand exceeds supply . . . demand inflation.

"Prices go higher when people are paid more without producing more . . . wage inflation.

"In either case somebody gets hurt: The buyer in the first case; the people who don't get a raise, in the second.

"The antidote to demand inflation is increased production, to end shortages.

"The antidote to wage inflation is increased productivity, to justify higher wages."

Timken Roller Bearing has been using this simple statement:

"A wage increase of $400 per employee will bring steel price increases.

"As steel goes so does inflation."

Below the signature is a quotation:

"The right to work shall not be abridged nor made impotent."

We thought of this when we read that pension funds have grown so rapidly that a sum of nearly $30 billion is now in pension reserves, with 14 million workers covered. You can get pretty mad thinking about the careless way in which some union leaders and some managers have handled these pensions that people have accepted as part of their wages. But the greatest thief in the world is not the dishonest manipulator of union welfare funds or any other kind of welfare pension funds. The greatest thief is *inflation.*

Data on Petroleum People Coming

Here is a letter from W. D. McEachron, Head of the Long-Range Planning Group, Standard Oil Company of Indiana: "I have read with considerable interest your excellent article on the annual report survey in the May 1957 issue of *The Petroleum Engineer.*

"In your summary of results you state that pay and benefits have increased 10 percent over 1956. However, information on pay and benefits is not shown in the tables perhaps due to the incomplete reporting by the companies involved.

"We are very much interested in obtaining available information on pay and benefits as well as number of employees. If you have data by companies in these areas, we would appreciate it if you could make them available to us."

You, too, may have wondered why the table on people was not included, although we did mention some percentages. This data will be used in a later article on stockholders and employees in the industry, and the amount of pay and benefits.

Anniversaries Make Stability

The longer a company has been in business, has expanded, and has operated successfully, the more credit we give it for being stable, resourceful, and progressive. Several milestones in anniversaries have been set this year by petroleum companies. The largest oil company in the world, Jersey Standard, has reached 75 years. Last month two others — Phillips Petroleum and Humble, an affiliate of Jersey Standard — each became 40 years old.

In the survey we make each year of annual reports, one table always has a column on the number of years in busi-

One Gas Panel Delivers Four Viewpoints

Below are four outstanding men — each important in his field. At Texas Independent Producers and Royalty Owners Association annual meeting each stated the case for his business and defended it in a two-day questioning period. Turn to Page E-3 and read what natural gas legislation means to Pipeliner J. J. Hedrick, Federal Power Commissioner W. R. Connole, Distributer J. E. Heyke, and Independent Producer Arch Rowan. You'll know more about the gas industry than ever before. You'll have a better idea of its operations and problems from gas exploration to gas legislation.

J. J. Hedrick

"Without off-peak sales pipelines cannot support load factors."

W. R. Connole

"Is human relations equal to the sum of the individuals" involved.

J. E. Heyke

"Gas sales prospects have a 'dry hole' ratio of 12 to 1 in Brooklyn."

Arch Rowan

"Utility-type pricing can be higher than you are able to sell gas for."

ness. According to this Standard of Ohio is the oldest company — 87 years; Atlantic Refining is 86; Continental has been in business 80 years; Standard of California and Tidewater are each 78 years old and Socony-Mobil began 74 years ago.

Unpopular With ADA

If we can't have sweetness and light from everybody we can be pleased to have the enemies we do have. One of the adversaries of the oil and gas industry is the Americans for Democratic Action. At a House Commerce Committee hearing the national director of the ADA said the "Monumental, unquenchable, and insatiable greed of the joint oil companies" would be the main beneficiaries of the natural gas legislation. If passed he said, it will result in higher gas prices. "We are talking about a bonanza of ten billion dollars, twenty billion dollars and even thirty billion dollars, most of which would fall into the laps of the big oil companies over the next several decades." The legislation, he said, would "enable a handful of oil companies to pick the pockets of sixty million American consumers."

1956 Dividend Higher

Writes A. V. Karcher, secretary-treasurer, Cosden Petroleum Corporation: "The information on dividends for Cosden is quite misleading. Before September 5, 1956, we were paying $1.50 per share. After a 2 for 1 split we paid $1.00 per year on the new stock."

He refers to the financial table carried on page A-18, May, 1957, of The Petroleum Engineer. We apologize for a mistake in copying the figures.

Financial Reports Made Simple

As we have mentioned several times there is a vast improvement in recent years in the presentation of operational and financial reports by companies in the petroleum industry. We think one reason for this is the distribution of "The Functional Operating Report Manual," published by The American Economic Foundation (295 Madison Avenue, New York 17, New York, price $1.00).

Written in 1947 by Robert R. Doane and Joseph E. Canning, both with the Foundation, the booklet had five printings of the first edition and two of the second. It simplifies the six-bit words used in many annual reports so that almost anyone who can read can understand. For depreciation and obsolescence it substituted "cost of tools wearing out" for instance. For those of you who struggle each year to make the annual report an accurate and presentable picture of your company, this is a good manual to have at your side.

Thanksgiving in July

What Sunray News said in its November 1956 issue for Thanksgiving actually fits any month:

"Never before in the history of civilization has man known such a bountiful life; never before have so many labor-saving devices existed; never before have so many luxuries been available to so many people. A farmer near Dubuque presses a button to start a tractor to till his acreage; a housewife in Albuquerque flips a switch to send her day's washing churning; a schoolboy in Shreveport turns a knob to watch the President's inauguration on television.

"Surely in a land of such bounty, in a land that offers its people the greatest security that man has ever known... surely every man, woman, and child will find time on Thanksgiving Day to pause in greatest humility and give thanks to God for the blessings of life in these United States."

Please Let *Us* Spend Our Money

We were one of those who wrote to the President and suggested we'd like to pay a little less income tax and spend that much more money ourselves. That might be termed selfish, but we felt, on the whole, we used more care in spending money we worked for than government people did. We received a very important letter from Mr. Sherman Adams and a reprinted message from the President on why all the vast sums were needed for the budget.

If you will pardon us, we'll admit we are more sold on the National Association of Manufacturer's analysis, showing how cuts amounting to $8,227,000,000 could be made in the proposed Federal budget. This would reduce the $71,800,000,000 for fiscal 1958 to $63,580,000,000 and the savings would give us a debt reduction and a tax reduction.

Most interesting aspect of taxes to us (outside of how to pay them) is that virtually every tax reduction results in the U. S. Treasury taking in more money. The GOP Congress reduced taxes over President Truman's veto, you remember, and the following year the budget was rather unexpectedly balanced.

Just to show we aren't entirely callous to finer things — like bigger budgets — we always put a word in for debt reduction before tax reduction. We suspect the generations coming up are not going to feel exuberant over paying our old debts.

A Friend to the Rescue

National Supply makes a good plea for the oil industry in an article published in its various plant publications and reprinted in a folder form. "Why Pick on Oil?" is a brief, readable essay on the oil industry. The writer says, "It (oil) has a good story to tell and nothing to hide." A copy is obtainable from the public relations department, The National Supply Company, 2 Gateway Center, Pittsburgh 22, Pennsylvania.

There's No Foretelling!

Does your company keep informed on the business outlook? In recent years more and more companies have been preparing their own forecasts as a basis on which to make company plans. A recent American Management Association research report based on replies from 56 companies indicates that nearly all this concern for business forecasts within the company has taken place within the last 10 years.

The booklet, Company Organization for Economic Forecasting,* gives 22 case histories in various businesses showing how the forecasts are used. From the case study some of the highlights revealed were:

... In some firms, the forecast goes only to top management; in others the forecaster acts as a consultant to several management levels and departments.

... The greatest value of forecasting internally, according to many firms, is that it contributes to and stimulates coordinated executive planning.

... Many firms report that the most important problem in forecasting is relating general trends to company plans.

*Published by American Management Association, Inc., 1515 Broadway, Times Square, New York 36, New York, 87 pp., price $3.

HIGHLIGHTS ★ ★ ★

Digest of News and Comment

Increase in depletion rate may be necessary to encourage more and deeper drilling needed to sustain adequate oil reserves, hints Gen. Ernest O. Thompson, Texas Railroad commissioner. Thompson suggested recently that the only way to keep from becoming dependent on foreign oil would be to retain the 27½ percent depletion — "or possibly increase it to 30 percent. Depletion recognition is far more important today than it was in 1926 when established by Congress, or at any time in our history."

★ ★ ★

Harris-O'Hara natural gas bill is back in the running and is again finding favor of most producers' organizations since President Eisenhower indicated that he would sign the bill even if it did not contain administration suggested amendments. The bill would relax some governmental controls over independent producers. Several leaders of the House of Representatives have already expressed belief that the measure would be sent through committee, passed and signed into law by the President this year.

★ ★ ★

Refinery run cutbacks marked June activity as product inventories piled up. R. W. McDowell, president of D-X Sunray Oil Company, warned that the industry "is drowning itself in a sea of refined products," and must curtail imports of foreign oil if a calamity is to be avoided by oil producers in the Southwest and Mid-Continent.

★ ★ ★

The Glenn McCarthy oil and gas properties are being purchased by Houston Natural Gas Corporation by agreement with the Equitable Life Assurance Society of the United States. The transaction, said to involve cash and production payments of some $7,000,000, is expected to be signed around August 1. In a separate statement, Tennessee Gas, Union of Louisiana, Lion Oil, and Murphy Corporation have announced that an option has been obtained on McCarthy's 900,000-acre concession in Bolivia.

★ ★ ★

U. S. motor vehicle registrations numbered 65,212,150 at the end of 1956, U. S. Bureau of Public Roads reports. This represents a four percent increase over the 1955 total. California leads the states in total registrations with 6,534,982. Nine states have 51.2 percent of the U. S. total, and 16 states have more than 1,000,000 registrations.

Nuclear radiation laboratories are now being built at Texaco Research Center in Beacon, New York. When completed, the labs are to be among the world's largest. According to Frederic H. Holmes, vice president, research and technical department, every possibility of using nuclear energy to practical advantage will be explored. One of three radiation sources in the lab will be a 6,000,000-v linear accelerator (first in oil industry).

★ ★ ★

Southern Natural Gas will be a fully integrated oil and gas company. The company has been negotiating for the purchase of Suntide Refinery at Corpus Christi, Texas. This would complete the Dallas-based company's across-the-board operations. Southern Natural is expected to pay $37,500,000 for assets of the 60,000 bbl per day (capacity) refinery.

★ ★ ★

Back to the "general store" sales technique is aim of a new program of Kerr-McGee Oil Industries. The company has unveiled a plan whereby it will market its gasoline on grocery supermarket parking lots. The stations, which have no meters or pumps above ground, permit housewives to have their cars serviced while they shop. Kerr-McGee is negotiating with National Foods Stores, Inc. for the first commercial installation at a supermarket in a St. Louis suburb.

★ ★ ★

Russia's Academy of Sciences is studying plans for construction of atomic-powered, ocean-going 25-30,000 ton tankers, according to the official government newspaper Izvestia. One survey indicated that transportation costs for oil and petroleum products in atom-powered tankers would be about 43 percent less than for conventional tankers. It said that the atom tanker would be 20 percent faster and have significantly-greater capacity for its size because it would not need to carry large quantities of fuel.

★ ★ ★

A crude oil price increase of four cents per barrel is needed to meet the general six percent wage increase given last month to oil employees, cites Robert L. Wood, IPAA president. Recent pay hike, Wood figures, will cost the industry about $100,000,000 annually. Production costs cannot be allowed to increase without boosting the price. Present price inadequacy, even before wage increases, is noted by the eight percent drop in well completions so far this year, said Wood.

Middle East crude price hikes initiated in June by British Petroleum affiliates have been welcomed by U. S. oilmen as lessening the threat of foreign competition. BP broke tradition by initiating increases rather than following price schedules set on the U. S. Gulf Coast. New prices are up 13 cents per bbl, FOB Abadan. Mobil Overseas Oil Company followed BP's lead, and was trailed by similar action of other Middle East operating companies.

★ ★ ★

Justice Department's annual report of the Interstate Oil Compact Commission, expected in late August or early September, may be expected to say little; Attorney General Brownell is not carrying out "to the letter," demand of Congress for such reports. Justice Department received no money to finance the investigation last year and did not ask for any this year. Brownell suggests that to make a conclusive report would require thorough investigation of the entire industry.

★ ★ ★

Tariffs might be used effectively to limit imports of petroleum to a reasonable amount, suggests J. C. Donnell II, president of Ohio Oil. Excessive dependence on foreign oil would endanger national defense, on the one hand, but undue rigid restriction would be harmful to foreign policy, he explained. One approach, he said, might be a sliding scale tariff which increased with distance from the United States, thus favoring Western Hemisphere's oil.

★ ★ ★

Oil industry will invest $60 billion in the next five years to meet the world's demand for oil products, says A. C. Long, board chairman of The Texas Company. By 1965, Long predicts, U. S. demand for oil products will increase 40 percent from present figures; demand from other non-Communist countries will increase as much as 115 percent. Approximately half of industry's outlay to meet this demand will be spent outside the U. S.

★ ★ ★

Tapline crude oil deliveries from Sidon, Lebanon, have set a new high of 380,038 bbl per calendar day. Trans-Arabian Pipe Line Company has announced that the big-inch line delivered 11,781,173 bbl in May, breaking its previous record set during October 1954. During May of last year, Tapline delivered 9,958,536 bbl, or an average of 321,243 bbl per calendar day.

It's no effort at all to reach the internals of this Peerless Gas Odorizer through the Sillers Flex-Ring Closure.

Sillers Flex Ring Closures are utilized on these large scrubbers at a Field Processing Plant in South Texas.

Here is a typical Sillers Flex Ring Closure installation on a Sillers Scraper trap on a products pipeline in Eastern Oklahoma.

Faster than ever before... SILLERS FLEX RING CLOSURES

The Perfect Closure for Boilers, Evaporators, Heat Exchangers, Autoclaves, Filters, Strainers, Absorbers and all types of Pressure Vessels and Piping Systems.

NEW, EASY SILLERS WAY

SILLERS FLEX RING CLOSURES give you many advantages and economies over the conventional flange type of closure, making the Sillers Closures about the most outstanding closure for the industry. LOW INITIAL COST . . . LESS TIME FOR OPENING AND CLOSING (JUST ONE BOLT) . . . TIGHTER SEALS AT HIGH PRESSURES . . . LESS WEIGHT . . . EASE OF HANDLING . . . and NO SEAL DESTRUCTION IN CASE OF FIRE, are just a few of the many advantages and features of the SILLERS FLEX RING CLOSURES. Sillers Closures are available in all standard sizes and can quickly be adapted for special applications.

Send for Bulletin No. 3900 for Completely Illustrated Details

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BOX 13165 DALLAS, TEXAS

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Representatives in Principal Cities

(1). Flex Ring Unit assembled as in service. (2). Spider released, gasket being removed. (3). After gasket is removed, plug is rotated to open. (4). Unit completely opened and in a fraction of time taken for conventional type closures.

An end to offshore drilling in California is seen by many leaders of many West Coast oil companies as a result of the state's new Tidelands Royalty Act. The bill was passed in mid-June over protests of many oilmen. It provides for a sliding scale royalty on all state-owned underwater acreage, starting at 16⅔ percent and going up with the value of the discovery. Olen Lane, Conoco, has indicated that the CUSS group will go out of the exploration business offshore. On the other hand, R. W. Ragland, Richfield Oil, says the new method will allow much wider bidding, inviting small oilmen to join in.

★ ★ ★

Close proximity relationship between segments of the oil industry has been vividly pointed out this past month by a series of events stemming from a strike at Crown Central Petroleum Corporation's Pasadena (Texas) refinery. For want of a market, Crown Central, also a purchaser, was unable to buy crude from a single producer, Wilson Exploration Company. Wilson crude withdrawals came from the Twofreds and Hazida fields in South Texas. The inability to dispose of production resulted in "unequal withdrawals from the reservoir," the state Railroad Commission immediately ruled and put the entire two fields on seven and eight day producing schedules — half the normal allowable. . . . "For want of a nail a battle was lost."

★ ★ ★

Drilling is "cautiously" picking up, say spokesmen for the Independent Petroleum Association of America, but are expressing doubt that the increased rig activity may be too little and too late to reach the 60,000 well mark that the industry has set for itself to meet oil reserve requirements. Most industry authorities agree that a number near the 58,270 well total reached in 1956 would be closer estimate for this year. Rig activity, in the first half of 1957, still lags nearly 10 percent behind last year's record.

★ ★ ★

API Citations for Service have been awarded to six oil leaders at the recent meeting of the Pacific Coast district of the API Division of Production. The awards were made to D. L. Connelly, vice president of Warren Petroleum Corporation, Dr. M. L. Barlow of the California State Department of Education, the late Ray Zell of Union Oil Company of California, J. K. Kellogg of K. L. Kellogg & Sons, F. T. Lloyd of Richfield Oil Corporation, E. A. Plunkett, and to Charles T. Reichert, both of National Supply Company.

★ ★ ★

Serious, but reserved, controversy marked the recent mid-year meeting of the Interstate Oil Compact Commission in the Yellowstone National Park, Wyoming. Nine state governors and two lieutenant governors were on hand to hear many-sided debates on the effects of curtailment of production of waterflood projects. It is expected that the subject will again be brought before IOCC's December meeting, and that a definite stand would be taken by the group at that time.

★ ★ ★

Domestic crude market during the third quarter of the year will drop about 400,000 bbl daily, the Independent Petroleum Association of America has predicted. IPAA stated that the market for this nation's crude is expected to average about 6,925,000 bbl daily, compared to the June production level of about 7,325,000 bbl daily. During the third quarter, market demand is at its lowest ebb.

★ ★ ★

Ownership of oil pipelines by the major companies may be the subject of a new Justice Department investigation. Such a move is being advocated by the staff of a Senate Judiciary subcommittee. Big oil companies, it declares, own or control over 90 percent of the nation's pipeline capacity and should be checked for possible violation of the antitrust laws.

Commercial gas customers in the United States are growing at a faster rate than retail business establishments. Volume of commercial gas sales has almost quadrupled since 1941. Americans spend more than $17½ billion per year on meals consumed outside the home, and nine out of ten of these meals are cooked with gas.

Leadership of the National Petroleum Council by an industry chairman is being threatened by a new bill being sent into the House of Representatives. The act would subject all advisory groups to the Department of Justice rules, as first suggested a few years ago by former President Truman. The new bill was unanimously reported by the House Government Operations Committee.

★ ★ ★

Anti-trust violation proceedings have been suggested for Arabian-American Oil Company by a Senate Judiciary subcommittee. The committee's staff report asserts that the company's four owners are sold crude at a uniform price, thus "removing Aramco from the world market insofar as the competitive disposal of its products is concerned and reduces the area of competition even as between the four owning companies." Stock acquisition is also questioned.

★ ★ ★

One day off a month with pay has been agreed to by drilling personnel of Carpenter-Trant Drilling Company of Denver, Colorado, and Casper, Wyoming. The arrangement was made during a series of leadership conferences by the company. The program, in operation since January, has brought about increased efficiency in operations. Taking part in the leadership conferences, led by M. L. Powers of the University of Oklahoma, are toolpushers, drillers, and derrickmen. Ultimate goal of Carpenter-Trant is a 40-hour week.

★ ★ ★

Over 56 billion gallons of gasoline was consumed in the United States last year, an annual API survey has revealed. This marks a new peak — 1¾ billion gallons above the previous high set in 1955. The figure includes both motor vehicle and off-highway consumption, but does exclude jet fuel from government sales, an item included in the 1955 reports. One-two-three order of consumption by states is California, Texas, and New York.

★ ★ ★

Felix E. Wormser stepped down last month from the post of assistant secretary of the interior to reenter private life. His services in the field of conservation of mineral resources were highly commended by President Eisenhower in a special letter of thanks. Wormser held the job over four years, although he stated from the beginning that it was a temporary assignment only to last a year.

Good Wells Make Good News

July 1, 1957

Dowell engineers can tailor acidizing to serve a variety of purposes and to give profitable results in a wide variety of formations. Here are some recent examples:

- **Harrison County, East Texas** (New Gas Well): The upper zone of a dual completion well was completed in a six-foot section of the Pettit oolitic lime at 6300 feet. Well was acidized with 500 gallons Mud Acid, 7000 gallons Dowell Retarded Acid and 7000 gallons Dowell Regular Acid. Two Allison-powered pumpers delivered acid down annulus at 2500 psi and 19 bpm. After treatment, well tested *40,000,000 cfpd open flow with 60 barrels petroleum liquids per million.*

- **Greenwood County, Kansas** (Old Well, Water Injection): Drilled in 1924 to Bartlesville sand (1847 to 1947 feet). Before acidizing, injection rate was 2 bwpd at 590 psi. Operator ran two-inch tubing and packer to protect casing. Well was treated by Dowell with 500 gallons Regular Acid followed by 50 pounds magnesium pellets suspended in 500 gallons water. 500 gallons Stabilized Acid was then injected at ¼ to ½ bpm. *Nearly one year after treatment injection rate was 287 bwpd at 505 psi.*

- **Park County, Wyoming** (New Well): Drilled into the highly soluble Phosphoria lime of the Silver Tip Pool. Open hole, 8620 to 8664 feet. Initial production—80 bopd. Analysis of sour crude indicated probable presence of iron sulfide in tubing. To prevent precipitation of iron hydroxide in formation, Dowell used Stabilized Acid. 3000 gallons were injected down 2½" tubing at 2.7 bpm and 1400 psi maximum. One week after treatment well was producing 130 bopd with no sign of plugging. *Operator considered these results unexpectedly good.*

- **Midland County, West Texas** (New Well): Completed in the Devonian dolomite 11,094 to 12,032 feet. Solubility averaged 88 per cent. Dowell pumped 40,000 gallons of Retarded Acid down casing annulus at 3800 psi. Average injection rate was 16 bpm. On test, well produced *312 bpd of 53.5 gravity oil through 18/64" choke.*

Dowell Engineers can select from over forty addition agents in tailoring acid treatments to your requirements. Furthermore, they are backed by unparalleled research facilities and experience. For more information or service, call any of the 165 Dowell offices in the United States and Canada; in Venezuela, contact United Oilwell Service. Or write Dowell Incorporated, Tulsa 1, Oklahoma.

Services for the oil industry

DOWELL

A Service Subsidiary of The Dow Chemical Company

Crews like to work with...

Youngstown ELECTRIC WELD LINE PIPE

BECAUSE IT GIVES THEM ALL THE BENEFITS OF THE "BIG 5"

Here are the "Big 5" reasons why Youngstown Electric Weld Line Pipe is your best buy:

1. It bends readily
2. Wall thickness is uniform
3. Line up characteristics are excellent
4. Weldability is outstanding
5. Long lengths save you time and trouble

Crews, contractors and oil and gas companies all like the time- and labor-saving "Big 5" benefits of Youngstown Electric Weld Line Pipe.

Youngstown Electric Weld Line Pipe saves time and trouble because it's made in long lengths. These long lengths, of course, result in minimum handling and welding—that speeds up installation and reduces pipe line costs.

Wherever there is oil and gas to be transported, there is Youngstown to serve you.

Youngstown Electric Weld Line Pipe

THE YOUNGSTOWN SHEET AND TUBE COMPANY
Manufacturers of Carbon, Alloy and Yoloy Steel
General Offices - Youngstown 1, Ohio
District Sales Offices in Principal Cities

Meetings

July 8-19—**Industrial Statistics for the Process Industries,** short course, sponsored by the Extension Division of the University of Oklahoma and the Chemical Division of the American Society for Quality Control, University of Oklahoma, Norman, Oklahoma.

Aug. 15—**API, OIC,** Steering Committee meeting, Biltmore Hotel, New York City.

Aug. 18-23—**National Congress of Petroleum Retailers,** 11th annual session, Sheraton Gibson Hotel, Cincinnati, Ohio.

Aug. 20-22—**Conference on Liquid Scintillation Counting.** Technological Institute, Northwestern University, Evanston, Ill.

Aug. 26-28—**Appalachian Gas Measurement Short Course,** 17th annual, West Virginia University, Morgantown, West Virginia.

Aug. 28-30—**International Symposium on Gas Chromatography,** Analysis Instrumentation Committee of the Instrument Society of America, Kellogg Center for Continuing Education, East Lansing, Michigan.

Aug. 30-31—**Association of Desk & Derrick Clubs of North America,** annual meeting, Hilton Hotel, Chicago, Illinois.

Sept. 3-5—**Pacific Coast Gas Association Convention,** San Francisco, California.

Sept. 5-6—**API Oil Information Committee meeting,** Broadmoor Hotel, Colorado Springs, Colorado.

Sept. 8-13—**American Chemical Society,** 132nd national meeting, New York City.

Sept. 9-11—**American Institute of Electrical Engineers,** petroleum industry conference, Sheraton Hotel, Philadelphia, Pennsylvania.

Sept. 9-13—**12th Annual Instrument Automation Conference and Exhibit,** sponsored by Instrument Society of America, Cleveland Auditorium, Cleveland, Ohio.

Sept. 10-11—**Petroleum Packaging Committee,** quarterly meeting, Hotel Guildwood Inn, Point Edward, Ontario, Canada.

Sept. 11-13—**National Petroleum Association,** 55th national meeting, Traymore Hotel, Atlantic City, New Jersey.

Sept. 12-14—**Wyoming Geological Association,** 12th annual field conference, Southwestern Wind River Basin, Lander, Wyoming.

Sept. 15-18—**AIChE,** Lord Baltimore Hotel, Baltimore, Maryland.

Sept. 22-24—**Independent Oil Compounders Association,** 10th annual meeting, Carter Hotel, Cleveland, Ohio.

Sept. 22-25—**American Society of Mechanical Engineers,** Petroleum Division, 12th annual Petroleum Mechanical Conference, Mayo Hotel, Tulsa, Oklahoma.

Sept. 23-24—**Steel Founders' Society of America,** 55th fall meeting, The Homestead, Hot Springs, Virginia.

Sept. 23-25—**American Society of Mechanical Engineers,** fall meeting, Statler Hotel, Hartford, Connecticut.

Sept. 26-27—**Western Petroleum Refiners Association,** regional technical-industrial relations meeting, Henning Hotel, Casper, Wyoming.

Sept. 26-27—**Louisiana-Arkansas Division Mid-Continent Oil & Gas Association,** annual membership meeting, Roosevelt Hotel, New Orleans, Louisiana.

Sept. 27—**Natural Gasoline Association of America,** Oklahoma regional, Skirvin Hotel, Oklahoma City, Oklahoma.

Sept. 30-Oct. 2—**American Oil Chemists' Society,** 1957 fall meeting, Netherland Plaza Hotel, Cincinnati, Ohio.

Oct. 1-2—**Texas Mid-Continent Oil & Gas Association,** 38th annual meeting, Texas Hotel, Fort Worth, Texas.

W-S Forged Steel Unions

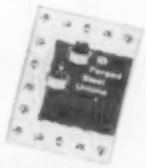
. . . these features tell the difference . . .

Not all forged steel fittings are alike. Careful design and precision manufacture give W-S Forged Steel Unions these important features that tell the difference:

1. Designed to AAR dimensional specifications.
2. Steel-to-steel seats, with spherical-to-angle mating surfaces. Angle is rolled to extra hardness to resist galling.
3. Cadmium plated nuts for resistance to corrosion and to galling and siezing.
4. End pieces protected against rust by new W-S blue synthetic coating.
5. Octagonal end pieces for better gripping.

W-S Unions are machined from forged steel in accordance with ASTM material specifications A-105, Grade 2. They are available with screw-end and socket-welding end pieces in 3000 lb. class, sizes ⅛" to 3".

For complete information send for Bulletin U-1. Write to W-S Fittings Division, H. K. Porter Company, Inc., P. O. Box 95, Roselle, N. J.



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H. K. PORTER COMPANY, INC.

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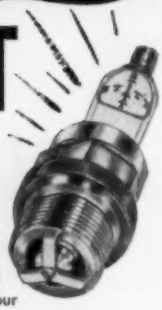

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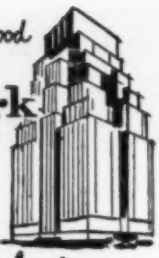

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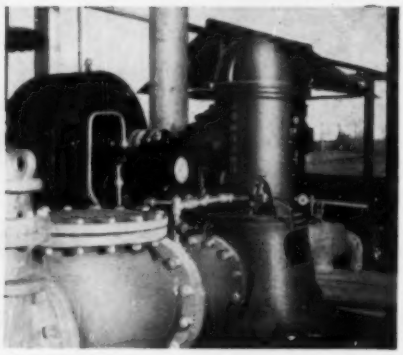

Photo Shows: Cooling Tower Application At Levelland, Texas

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Oct. 1-2—**API Executive Committee of Board of Directors,** Greenbrier Hotel, White Sulphur Springs, West Virginia.

Oct. 6-9—**The Society of Petroleum Engineers, AIME,** 32nd annual fall meeting, Adolphus, Baker and Statler Hilton hotels, Dallas, Texas.

Oct. 6-10—**ASTM Committee D-2 meeting,** Sheraton-Park Hotel, Washington.

Oct. 7-9—**ASME, ASLE-ASME Lubrication Conference,** Royal York Hotel, Toronto, Ontario, Canada.

Oct. 7-9—**American Gas Association,** annual convention, Kiel Auditorium, St. Louis, Missouri.

Oct. 7-9—**National Electronics Conference,** co-sponsored by Illinois Institute of Technology and two other universities and two technical societies, Hotel Sherman, Chicago, Illinois.

Oct. 7-11—**American Institute of Electrical Engineers,** 1957 fall general meeting, Morrison Hotel, Chicago, Illinois.

Oct. 10-12—**ASME, Fuels-AIME conference,** Chateau Frontenac, Quebec City, Quebec, Canada.

Oct. 13-15—**American Association of Oil-well Drilling Contractors,** 17th annual meeting, Mayo Hotel, Tulsa, Oklahoma.

Oct. 13-16—**American Petroleum Credit Association,** 33rd annual conference, Mark Hopkins Hotel, San Francisco, California.

Oct. 16-17—**South Dakota Independent Oil Men's Association convention,** Alonzo Ward Hotel, Aberdeen, South Dakota.

Oct. 17-18—**The Society of Petroleum Engineers, AIME,** Southern California Petroleum Section, fall meeting, Biltmore Hotel, Los Angeles, California.

Oct. 20-22—**National Association of Oil Equipment Jobbers,** annual convention and trade show, Hotel Peabody, Memphis, Tennessee.

Oct. 21-23—**American Society of Mechanical Engineers,** conference on development in the field of power, Allentown, Pennsylvania.

Oct. 23-24—**Computer Applications Symposium,** sponsored by Armour Research Foundation, Hotel Sherman, Chicago, Illinois.

Oct. 24-25—**Western Petroleum Refiners Association,** regional technical-industrial relations meeting, Rufus Garrett Hotel, El Dorado, Arkansas.

Oct. 25—**Natural Gasoline Association of America,** southern regional, Washington-Youree and Captain Shreve hotels, Shreveport, Louisiana.

Oct. 27-29—**Independent Petroleum Association of America,** annual meeting, Statler-Hilton Hotel, Dallas, Texas.

Oct. 31-Nov. 1—**AAPG Mid-Continent** regional meeting, Cimarron Ballroom, Tulsa Oklahoma.

Nov. 6-8—**Gulf Coast Association of Geological Societies,** 7th annual convention, Roosevelt Hotel, New Orleans, Louisiana.

Nov. 11-13—**Steel Founders' Society of America,** 12th Technical and Operating Conference, Carter Hotel, Cleveland, Ohio.

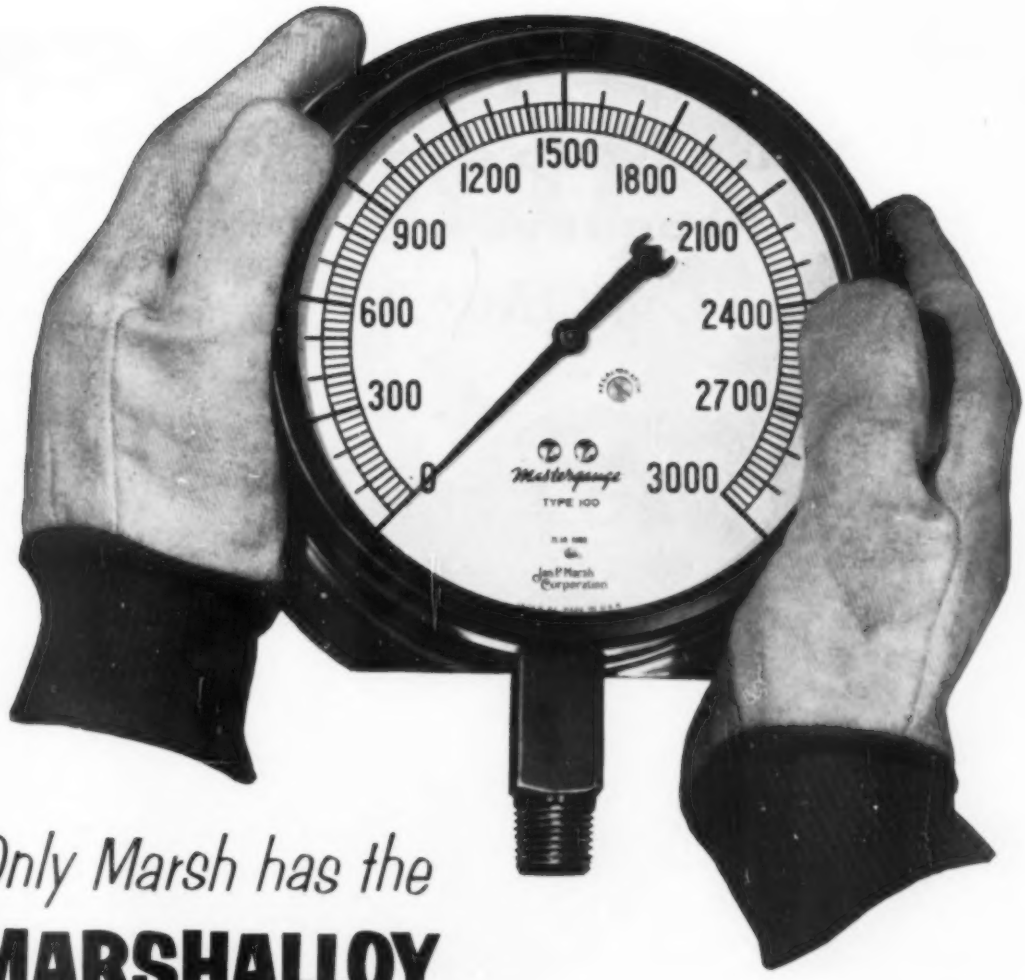
Nov. 11-14—**API,** 37th annual meeting, Conrad Hilton Hotel and Palmer House, Chicago, Illinois.

Nov. 12-14—**National Association of Corrosion Engineers,** Northeast region, fall meeting, Penn-Sheraton Hotel, Pittsburgh, Pennsylvania.

Nov. 13-14—**Air Pollution Conference,** co-sponsored by Armour Research Foundation and Midwestern Air Pollution Prevention Association, Loop Hotel, Chicago, Illinois.

Nov. 22—**Natural Gasoline Association of America,** Panhandle Plains regional, Herring Hotel, Amarillo, Texas.

Dec. 8-11—**American Institute of Chemical Engineers,** annual meeting, Conrad Hilton Hotel, Chicago, Illinois.



Only Marsh has the

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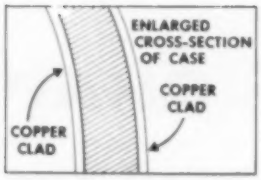

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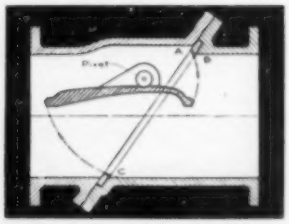

Look at this operational chart. When the flow is on, "airfoil" disc is held firmly against stops in the body. When the flow drops, disc balances quietly on whatever flow there is. When flow stops, disc drops quickly, quietly and firmly on special bevel seat. Note that sufficient space is designed around disc to cut down flow resistance.

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... with full-rated vapor and product capacity at all times

... with a membrane that cannot come in contact with product

... with vapor space that can be isolated for inspection and maintenance without taking tank out of service.

Principle of the Hammond Dialift

A—DIALIFT DIAPHRAGM rises and falls to accommodate expanding and contracting vapor.

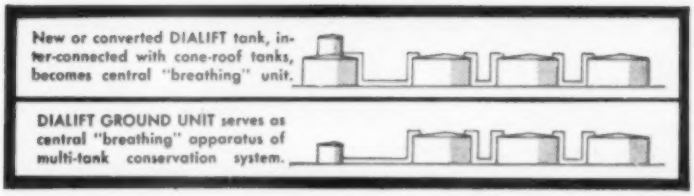
B—Vapor passes to and from tank and DIALIFT through simple elbow connection.

C—DIALIFT and tank have full-rated capacity.

D—Membrane can't come in contact with product.

E—DIALIFT can be isolated for maintenance and inspection, product tank stays in service.

The most efficient and economical vapor conservation system for new or old tanks.


New or converted DIALIFT tank, inter-connected with cone-roof tanks, becomes central "breathing" unit.
DIALIFT GROUND UNIT serves as central "breathing" apparatus of multi-tank conservation system.

THE HAMMOND DIALIFT consists of a gas-tight Vulcalock membrane attached to the inside periphery of a cylindrical metal housing to become a "breathing" apparatus to accommodate the expanding and contracting vapor as developed in product storage tanks. The DIALIFT can be used as a single conservation unit by being attached to the roof of a product storage tank or as a central "breathing" system by being manifolded to a number of product storage tanks. There are two forms of installation:—Ground type manifolded to a number of tanks to form a conservation system and integrated type whereby the DIALIFT is attached to the roof of a tank for vapor conservation for one or a number of tanks. The DIALIFT is completely isolated from the product storage tank. Vapor passes between the tank and DIALIFT through a vaporline connection. It is easy to convert old cone roof tanks to efficient vapor-saving DIALIFT installations by attaching a DIALIFT housing with membrane to the roof of the old tank and connecting the vaporline between the tank and DIALIFT.

THE HAMMOND DIALIFT ELIMINATES BREATHING LOSS AND REDUCES FILLING LOSS

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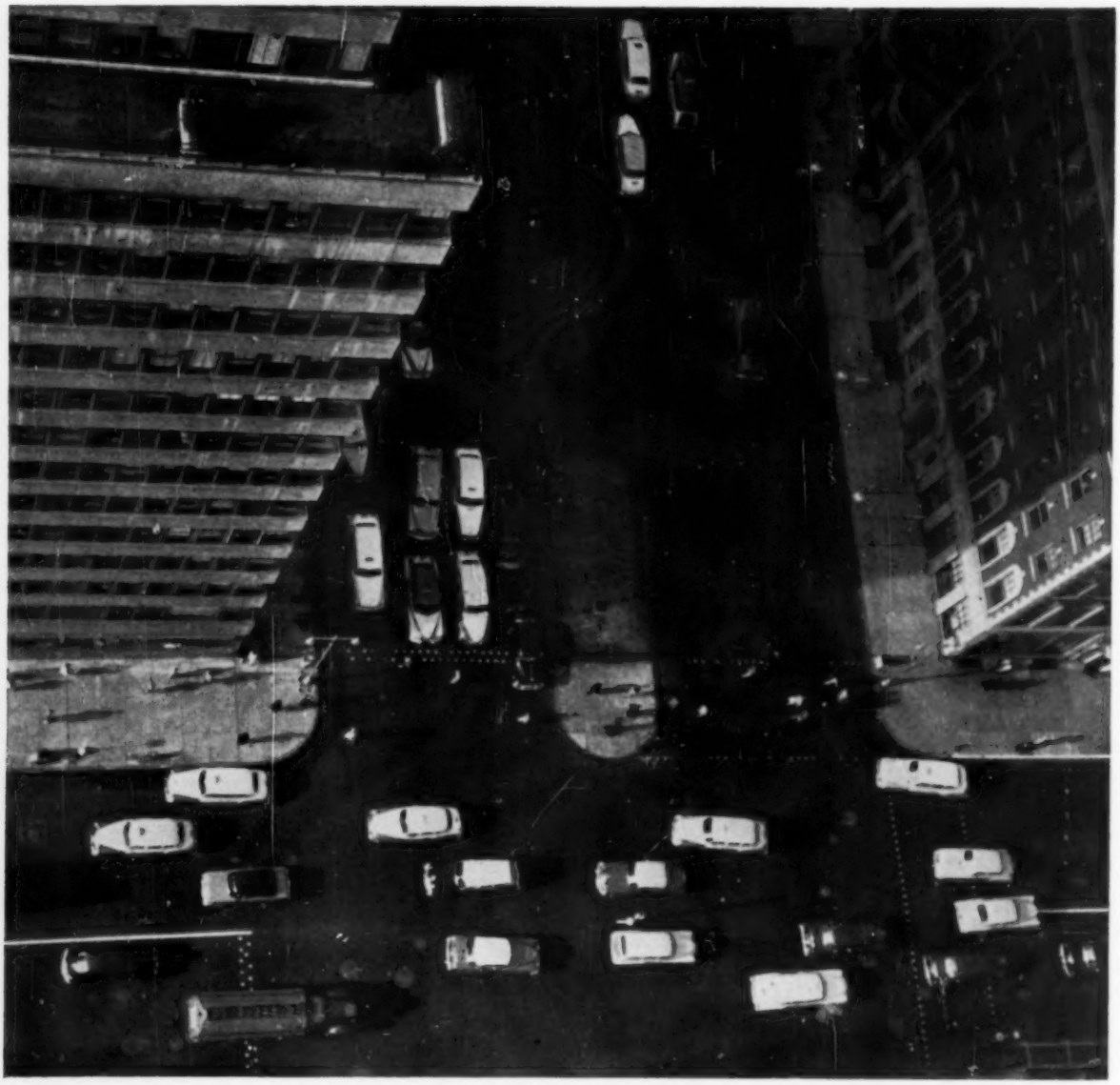

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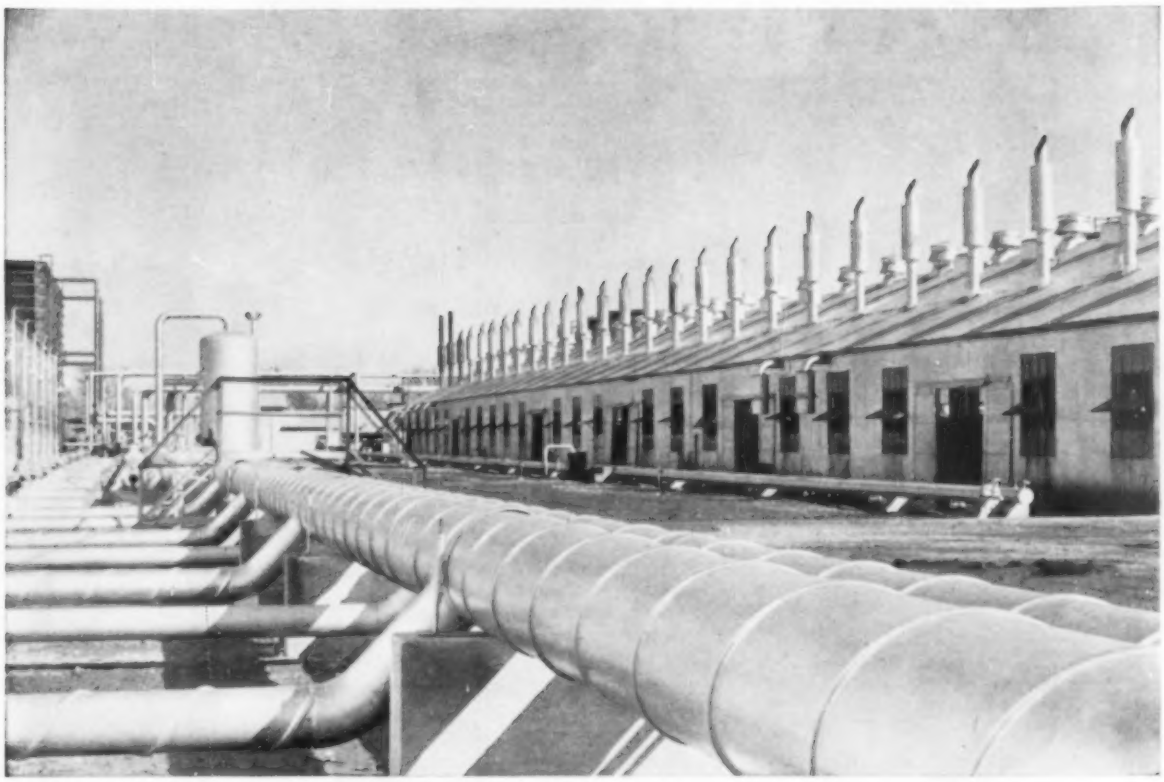

Like the modern "freeway," Naylor Spiralweld pipe stands out in service as well as in appearance. The familiar spiral that distinguishes this lightweight pipe makes it stronger and safer in pipe line performance.

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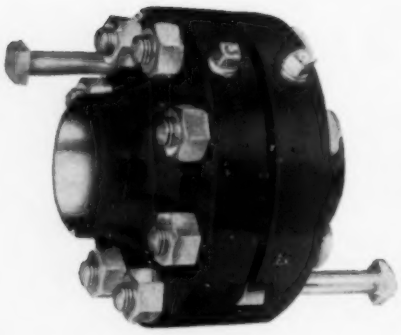

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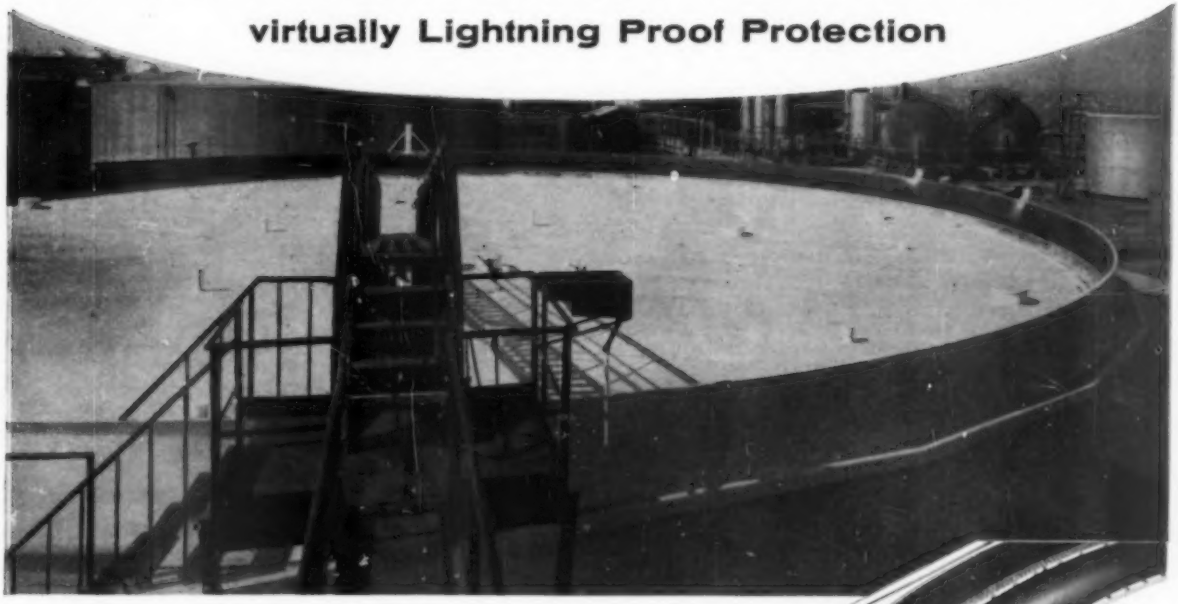
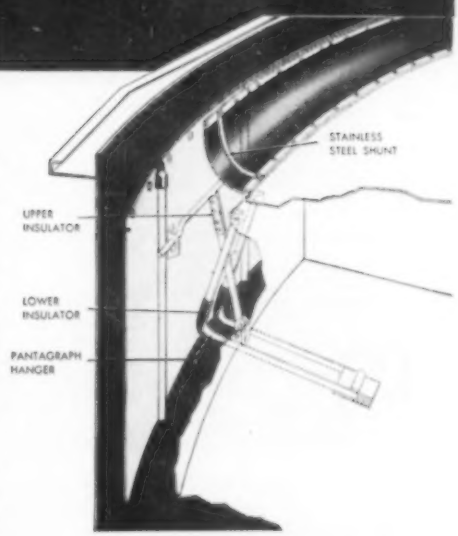
NEW Insulated Pantagraph Hangers available with HORTON FLOATING ROOFS provide virtually Lightning Proof Protection



A new pantagraph hanger, designed by CB&I for use with the Horton® Seal, has a large number of shunts spaced equally around the roof above the seal fabric. The underseal hangers are insulated so that the current induced by lightning must pass through the shunts. This eliminates the possibility of sparks in the rim space. Ignition cannot occur when lightning strikes on or near the tank.

All floating roofs have a rim space which may contain a flammable mixture. The important thing is to avoid a source of ignition in the vapor space. The new CB&I design of shunts and insulators eliminates the possibility of ignition by lightning-induced sparks. Now you can have lightning protection in addition to proven safety from exposure fires.

Horton Seals equipped with CB&I's new insulated pantagraph hangers are available on Horton Double-Deck, Pontoon and Pan Floating Roofs. Complete information, estimates or quotations may be obtained by writing our nearest office.



Cutaway view of a Horton Seal with new insulated pantagraph hanger designed to provide virtually lightning proof protection. Insulation on underseal hangers prevent lightning induced currents from passing through them and large area stainless steel shunts carry currents from the floating roof across the fabric and to the tank shell.

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P-43C

WEIGHT INDICATOR CONVERSION TABLES

TABLE 2. Conversion table for gage readings on weight indicator with 1⅛-in. cable—*Continued.*

Gage reading points	Number of lines						
	1	2	4	6	8	10	12
45	14800	29600	59200	88800	118400	148000	177600
46	15240	30480	60960	91440	121920	152400	182880
47	15690	31380	62760	94140	125520	156900	188280
48	16140	32280	64560	96840	129120	161400	193680
49	16590	33180	66360	99540	132720	165900	199080
55	17050	34100	68200	102300	136400	170500	204600
56	17515	35030	70060	105090	140120	175150	210180
57	17985	35970	71940	107910	143880	179850	215820
58	18460	36920	73840	110760	147680	184600	221520
59	18940	37880	75760	113640	151520	189400	227280
	19425	38850	77700	116550	155400	194250	233100
50	19915	39830	79660	119490	159320	199150	238980
51	20410	40820	81640	122460	163280	204100	244920
52	20910	41820	83640	125460	167280	209100	250920
53	21410	42820	85640	128460	171280	214100	256920
54							
60	21920	43840	87680	131520	175360	219200	263040
61	22430	44860	89720	134580	179440	224300	269160
62	22945	45890	91780	137670	183560	229450	275340
63	23460	46920	93840	140760	187680	234600	281520
64	23980	47960	95920	143880	191840	239800	287760
65	24500	49000	98000	147000	196000	245000	294000
66	25025	50050	100100	150150	200200	250250	300300
67	25550	51100	102200	153300	204400	255500	306600
68	26100	52200	104400	156600	208800	261000	313200
69	26650	53300	106600	159900	213200	266500	319800
70	27225	54450	108900	163350	217800	272250	326700
71	27800	55600	111201	166800	222400	278000	333600
72	28400	56800	113600	170400	227200	284000	340800
73	29000	58000	116000	174000	232000	290000	348000
74	29600	59200	118400	177600	236800	296000	355200

Gage reading points	Number of lines						
	1	2	4	6	8	10	12
75	30200	60400	120800	181200	241600	302000	362400
76	30800	61600	123200	184800	246400	308000	369600
77	31400	62800	125600	188400	251200	314000	376800
78	32000	64000	128000	192000	256000	320000	384000
79	32610	65220	130440	195660	260880	326100	391320
80	33220	66440	132880	199320	265760	332200	398640
81	33830	67660	135320	202980	270640	338300	405960
82	34440	68880	137760	206640	275520	344400	413280
83	35050	70100	140200	210300	280400	350500	420600
84	35675	71350	142700	214050	285400	356750	428100
85	36300	72600	145200	217800	290400	363000	435600
86	36925	73850	147700	221550	295400	369250	443100
87	37550	75100	150200	225300	300400	375500	450600
88	38190	76380	152760	229140	305520	381900	453280
89	38830	77660	155320	232980	310640	388300	465960
90	39470	78940	157880	236820	315760	394700	473640
91	40110	80220	160440	240660	320880	401100	481320
92	40750	81500	163000	244500	326000	407500	489000
93	41395	82790	165580	248370	331160	413950	496740
94	42040	84080	168160	252240	336320	420400	504480
95	42685	85370	170740	256110	341480	426850	512220
96	43330	86660	173320	259980	346640	433300	519960
97	43975	87950	175900	263850	351800	439750	527700
98	44620	89240	178480	267720	356960	446200	535440
99	45265	90530	181060	271590	362120	452650	543180
100	45910	91820	183640	275460	367280	459100	550920

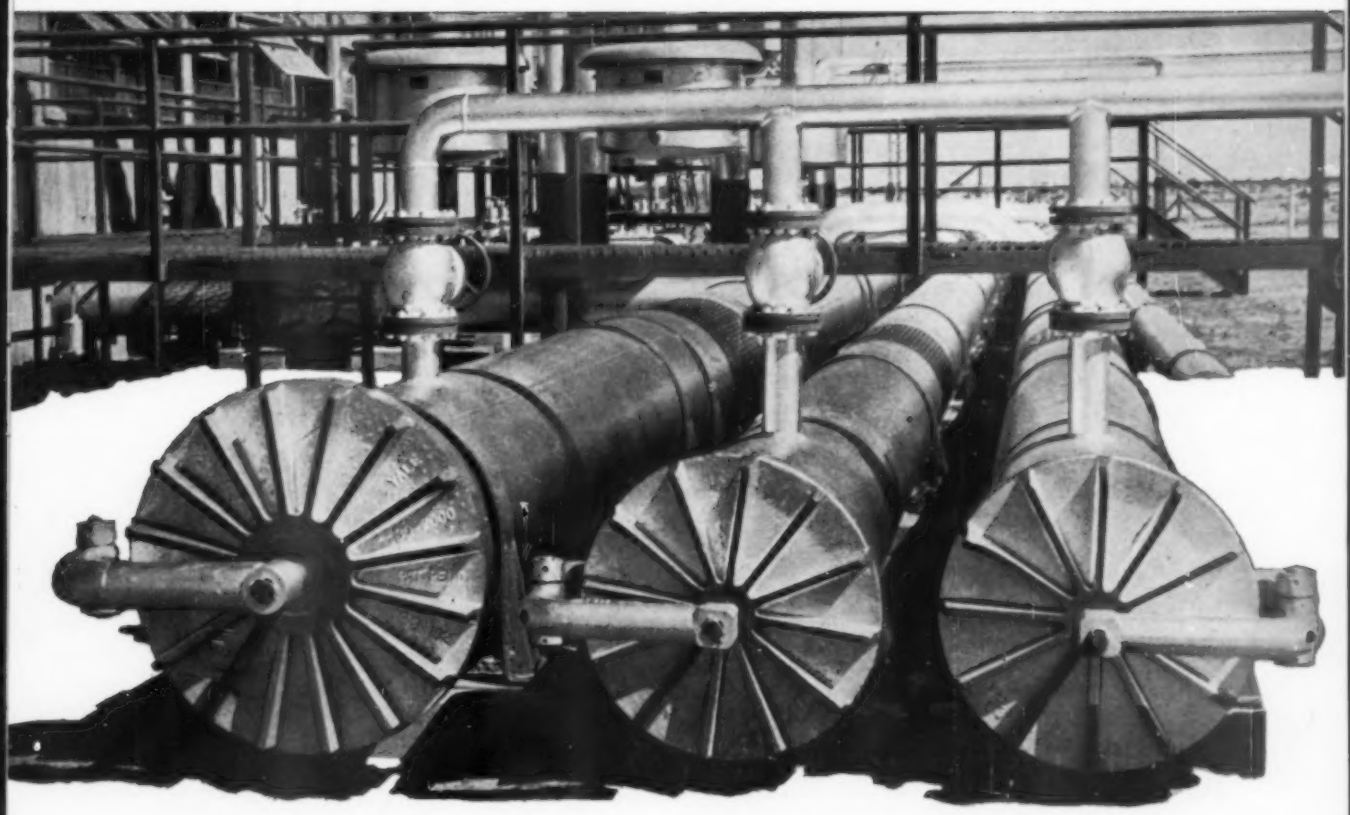
Average value of one indicator point in pounds for obtaining bit pressure in pounds—1⅛-in. drilling line.

Between gage readings below	Number of lines						
	1	2	4	6	8	10	12
5–10	309	618	1236	1854	2472	3090	3708
10–20	328	656	1312	1968	2624	3280	3936
20–30	347	694	1388	2082	2776	3470	4164
30–40	393	786	1572	2358	3144	3930	4712
40–50	438	876	1752	2628	3504	4380	5256
50–60	487	974	1948	2922	3896	4870	5844
60–70	531	1062	2124	3186	4248	5310	6372
70–80	600	1200	2400	3600	4800	6000	7200
80–90	625	1250	2500	3750	5000	6250	7500
90–100	644	1288	2576	3864	5152	6440	7728

TABLE 3. Conversion table for gage readings on weight indicator with 1¼-in. cable.
Refer to Sheet 1 for adjustment procedure.

Gage reading points	Number of lines						
	1	2	4	6	8	10	12
5	200	400	800	1200	1600	2000	2400
6	490	980	1960	2940	3920	4900	5880
7	780	1560	3120	4680	6240	7800	9360
8	1070	2140	4280	6420	8560	10700	12840
9	1360	2720	5440	8160	10880	13600	16320
10	1650	3300	6600	9900	13200	16500	19800
11	1950	3900	7800	11700	15600	19500	23400
12	2250	4500	9000	13500	18000	22500	27000
13	2550	5100	10200	15300	20400	25500	30600
14	2850	5700	11400	17100	22800	28500	34200
15	3150	6300	12600	18900	25200	31500	37800
16	3470	6940	13880	20820	27760	34700	41640
17	3790	7580	15160	22740	30320	37900	45480
18	4110	8220	16440	24660	32880	41100	49320
19	4430	8860	17720	26580	35440	44300	53160
20	4750	9500	19000	28500	38000	47500	57000
21	5090	10180	20360	30540	40720	50900	61080
22	5430	10860	21720	32580	43440	54300	65160
23	5770	11540	23080	34620	46160	57700	69240
24	6110	12220	24440	36660	48880	61100	73320

—Courtesy Martin-Decker Corporation, Long Beach, California.



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The use of 2-Piece Blank Caps on headers, traps, scrapers and blowdowns will effect great savings in **your** systems. They are furnished in every size from 2" through 38", ASA Series 400, 600 and 900. Easy-swinging hinges are available for all sizes, for horizontal or vertical installation. For complete information, write for Catalog No. 56.

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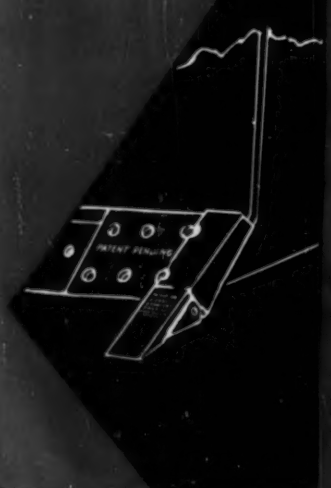

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- Corner points stay sharp — Eliminates round corners

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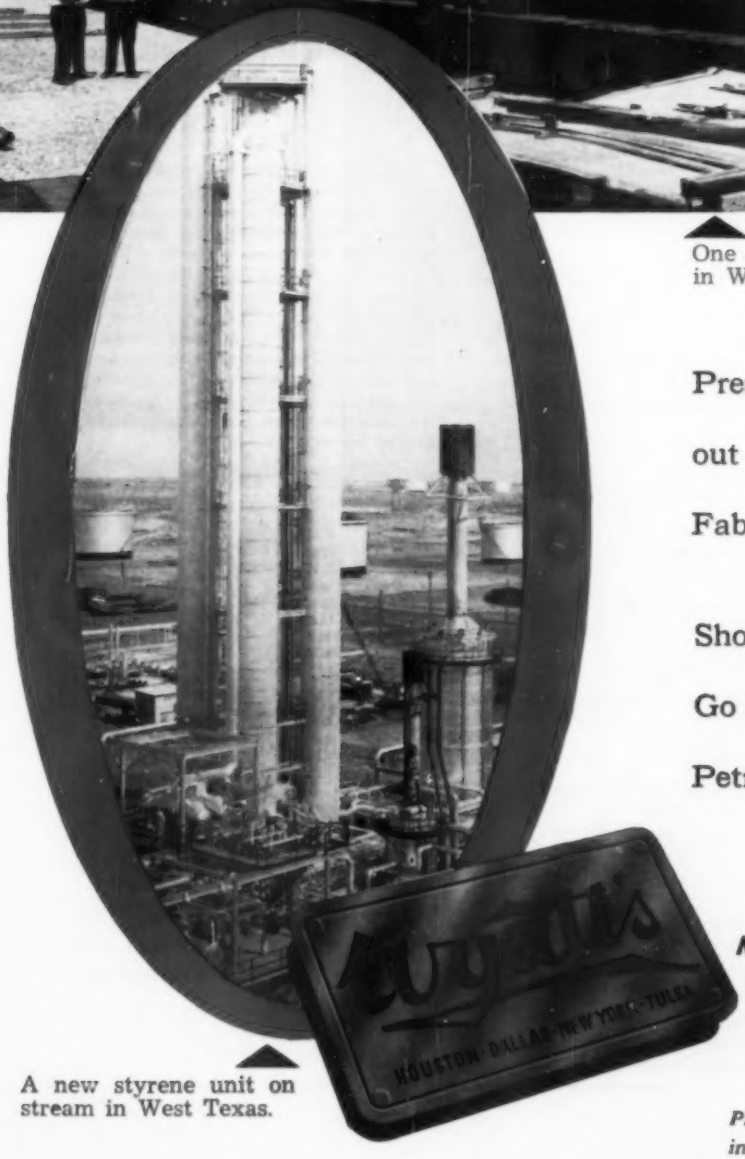
ROUTINE PROCEDURE

One of the four towers fabricated in Wyatt's Houston shops.



A new styrene unit on stream in West Texas.

Pressure Vessels move

out of Wyatt's

Fabrication Shops

Shortly New Units

Go on Stream in

Petrochemical Processing

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Plastic Lining is the Growing Trend in Mastering Corrosion...
Consult **WYATT'S PLASTICS, INC.**
Subsidiary, Wyatt Metal & Boiler Works

METHODS OF CALCULATING BOTTOM-HOLE PRESSURES IN GAS WELLS

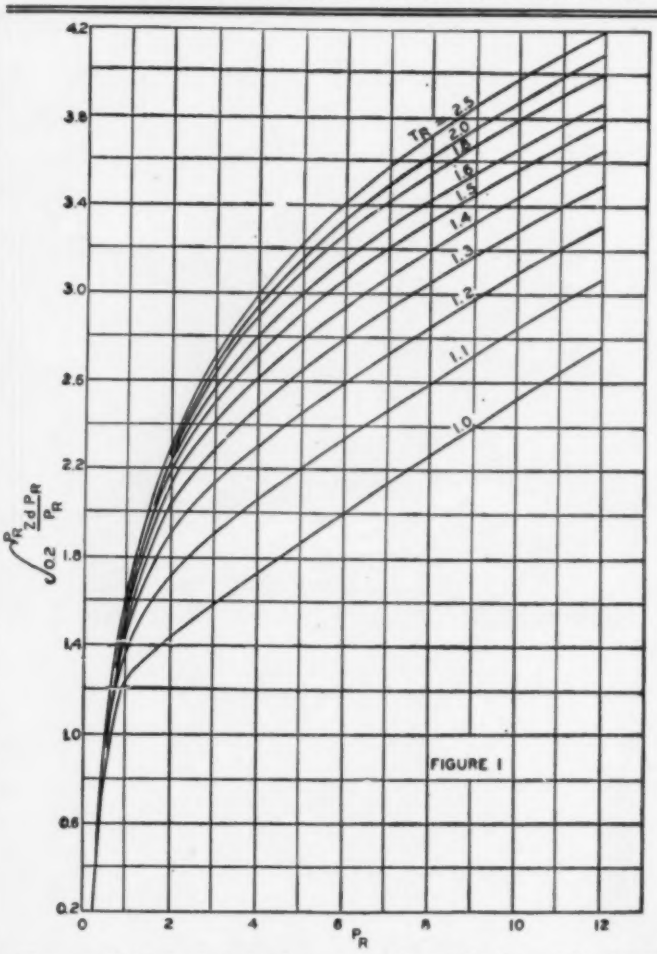


FIGURE 1

Three methods of calculating bottom-hole pressure are discussed and compared by Rzasa and Katz[5] with an actual bottom-hole pressure measured in a gas well[2]. All three methods require a trial and error solution.

A method involving a direct solution and obviating the trial-error solution for calculating bottom-hole pressure is presented in this article. The accuracy of this method is comparable to the two shorter methods given in the article by Rzasa and Katz[5].

● **Derivation of equation.** In a column of fluid of uniform composition, the following differential equation can be applied to the change in pressure, dP, over a height of fluid, dh, having density, ρ:

$$dP = \rho dh \quad \ldots\ldots\ldots \quad (1)$$

Using compressibility factors, the density, ρ, can be expressed as:

$$\rho = \frac{MP}{ZRT} \quad \ldots\ldots\ldots \quad (2)$$

Where:

ρ = density, lb per cu ft,

M = molecular weight of fluid,

P = pressure, psf,

R = 1544 psfa, cu ft per lb mole, °R,

T = absolute temperature, °F + 460, and

Z = compressibility factor.

Substituting equation (2) into equation (1):

$$dP = \frac{MPdh}{ZRT} \quad \ldots\ldots\ldots \quad (3)$$

Rearranging and integrating equation (3):

$$\int_{P_1}^{P_2} \frac{ZTdP}{P} = \frac{(h_2 - h_1)\,M}{R} \quad \ldots \quad (4)$$

$(h_2 - h_1)$ represents the length of fluid between pressures P_2 and P_1.

For simplification, $(h_2 - h_1)$ will be replaced with h representing the height or depth of fluid in the well.

Removing the temperature, T, from the integral by replacing it with the proper average temperature T_a, equation (4) becomes:

$$\int_{P_1}^{P_2} \frac{ZdP}{P} = \frac{hM}{RT_a} \quad \ldots\ldots \quad (5)$$

Equation (5) can be graphically integrated by using compressibility charts. As compressibility charts are customarily placed on a general basis of reduced temperature and pressure, there is no reason why the above integration cannot be carried through on the same general basis.

By definition:

$$P_r = \frac{P}{P_c} \quad \ldots\ldots\ldots \quad (6)$$

Where:

P_r = reduced pressure,

P_c = critical pressure of fluid (abs), and

P = pressure of fluid (abs).

From equation (6):

$$dP = P_c dP_r \quad \ldots\ldots\ldots \quad (7)$$

Substituting equations (6) and (7) into equation (5):

$$\int_{P_{r,1}}^{P_{r,2}} \frac{ZdP_r}{P_r} = \frac{hM}{RT_a} \quad \ldots\ldots \quad (8)$$

Integration of equation (8) has been completed graphically, using compressibility factors for methane published by Brown[1]. This integration has been carried out between pressure limits of P_r = 0.2 and P_r extending to a value of 12 for constant reduced temperatures between 1.0 and 2.5. The results are shown in Fig. 1. The choice of the lower pressure limit P_r = 0.2 was purely arbitrary and any other value might have been chosen. The integral used is between limits so that absolute values from zero pressure are not necessary.

Although a rigorous solution indicates that the arithmetic average of wellhead and bottom-hole temperatures is not strictly the proper average, the error introduced by this type of average is generally small. The temperature gradients of shut-in gas wells have been reported in the literature. The gradients are essentially linear after a depth of 2000 ft has been exceeded. Temperature gradients vary with different fields. Two typical gradients are presented in Fig. 2. One is taken from the article of French[3] for the Wasco field, California, and the other is from the article of Eilerts and Schellhardt[2] for a well in the East Texas field.

Literature cited.

1. Brown, *The Petroleum Engineer, 11*, No. 4, 21 (1940).
2. Eilerts and Schellhardt, *U. S. Bureau of Mines, R. I.* 3402 (1938).
3. French, *Oil and Gas Journal, 37*, No. 50, 48 (1939).
4. Katz, *Ref. and Nat. Gasoline Mfr., 21*, No. 6, 53 (1942).
5. Rzasa and Katz, *A.I.M.E. Transactions, 160*, 113 (1945).
6. Standing and Katz, *A.I.M.E. Transactions, 146*, 140 (1942).

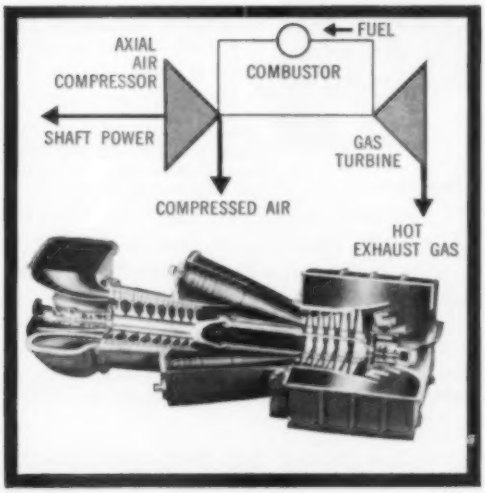
NOTE: Nomenclature is shown on Sheet 2, P 509.1. Taken from the article "Calculations of Bottom-Hole Pressures," by Frank C. Fowler in *The Petroleum Engineer*, March, 1947, pages 87 to 91, inclusive.

3 FROM 1

Shaft power, compressed air, heat... all from one gas turbine...

BY TAKING ADVANTAGE of the versatile Westinghouse gas turbine, engineers are simplifying many processes. For example . . .

As gasifiers—In a large Southwestern butadiene plant, four Westinghouse gas turbines will soon be operating as gasifiers for the reactivation of the catalyst and each will eliminate the need for a separate prime mover and a separate air compressor.



In addition, smaller line heaters and less fuel will be used because *all* the *Btu's* put into the gas turbine are exhausted to the heaters and process, with the exception of minor radiation and bearing losses.

Versatility—The modern Westinghouse gas turbine can be used to streamline processes, for it offers many combinations of output:

Shaft power.....up to 22,500 hp
Compressed air.....up to 85 psia
Hot gas (18% oxygen).....up to 1000°F

Ask today for your set of suggested process sketches. Contact your Westinghouse representative, or write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-50598

YOU CAN BE SURE...IF IT'S Westinghouse

Let's get technical about WALWORTH LUBRICATED PLUG VALVES for pipeline service

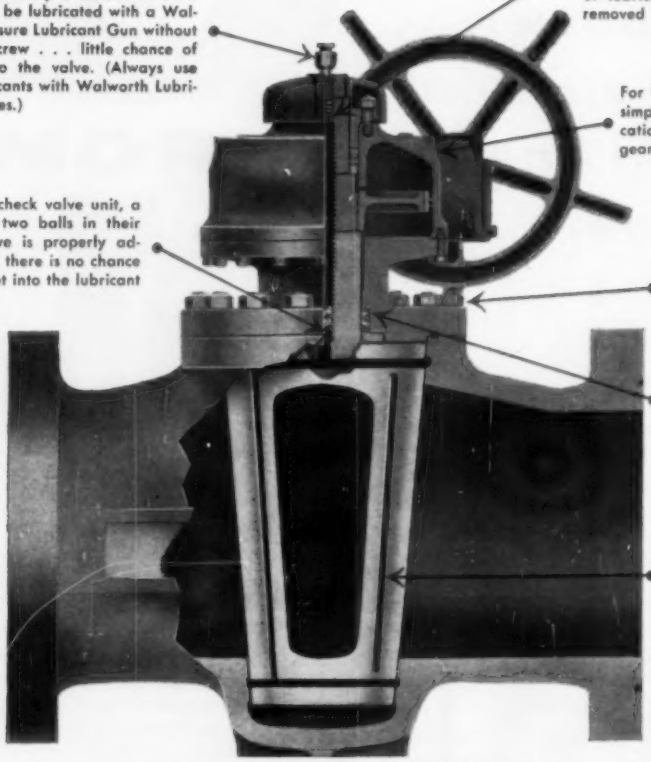
Combination button-head lubricant fitting and lubricant screw is provided at no extra cost. Valves can be lubricated with a Walworth High Pressure Lubricant Gun without removing the screw . . . little chance of grit getting into the valve. (Always use Walworth Lubricants with Walworth Lubricated Plug Valves.)

An added safety feature in the form of a groove cut part way up side of the lubricant-fitting screw allows the operator to observe any tendency of lubricant to blow out before the screw is removed entirely.

For buried pipelines — yoke design permits simple attachment of handwheel and lubrication extensions without modifying the gearcase.

In the stainless steel check valve unit, a transverse pin holds two balls in their seats. When the valve is properly adjusted and lubricated, there is no chance for line pressure to get into the lubricant system.

Standard bolt threads, rather than fine threads, mean easy replacement of nuts and bolts from local stocks.



Two overlapping Teflon packing rings form an effective seal against possible leakage without "grabbing" the plug shank. Low breakout torque . . . plug turns easier. Packing serves only as a seal and is not used to hold the plug in its seat.

Lubricant grooves completely frame the port openings and encircle the plug at the top and bottom assuring a tight seal against leaks. Bottom circumferential groove is separate from, but connected with, the lubricant well.

Other Walworth Lubricated Plug Valves include Single Gland and Regular Gland types. Sizes to 30 inches. Pressures to 5000 psi. and for vacuum service.

Cutaway of a 24-inch Walworth Lubricated Plug Valve

Without exception, a Walworth Ball Bearing Lubricated Plug Valve is easier to operate and maintain than any other type of rotary-action, sealed valve available today for pipeline service. Design features pointed out here show just a few advantages of Walworth Ball Bearing Lubricated Plug Valves.

Many pipeline companies throughout the world use Walworth valves for handling gas, crude, and finished products. Investigate the line of Walworth valves for your own needs. See your Walworth Distributor, or write for literature: Walworth Company, General Offices, 60 East 42nd Street, New York 17, N. Y.

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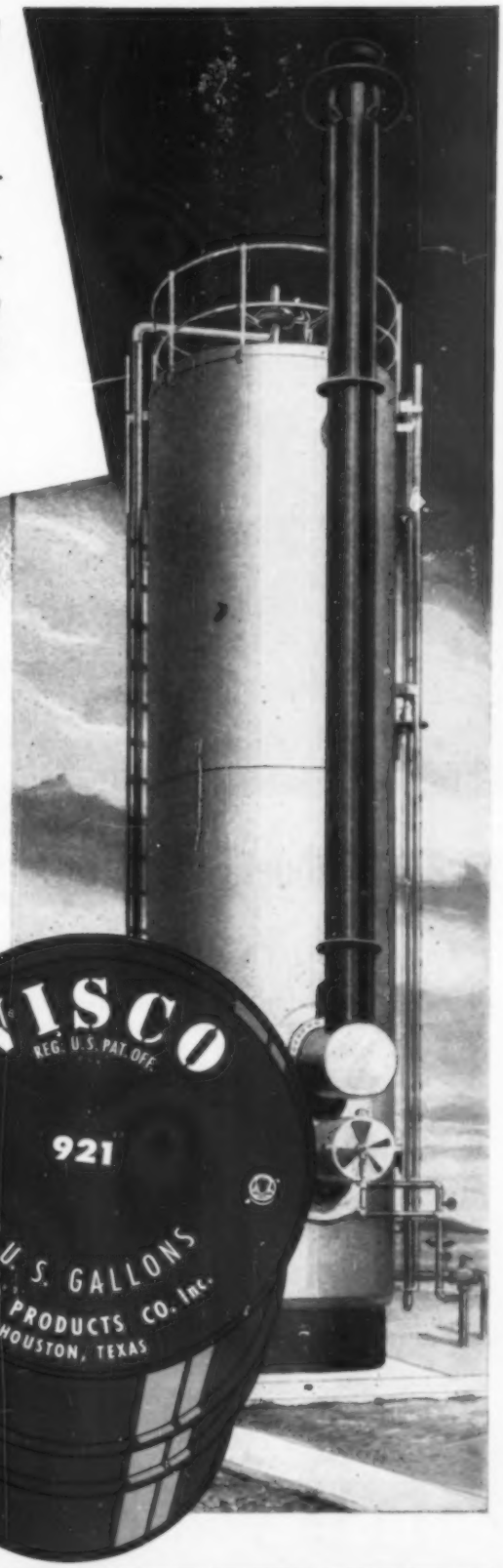
"...based on Visco paraffin-removal experience such as these, other producers should be interested in this method..."



THE SITUATION: Gun barrel contained 84 barrels of paraffin, 28 barrels of oil, plus water-wash.

WHAT WAS DONE: 10 gallons of Visco 921 Paraffin Dispersant in 10 gallons of crude was put into the gun barrel. Vessel was rolled for two hours with an exhaust hose from just above the water-oil interface. 14 bbl./day well on the lease was left running—no down time.

WHAT HAPPENED: Paraffin content of gun barrel cut from 84 barrels to 30 barrels. Only 0.2% paraffin could be ground out of oil on top of the vessel.

WHAT IT COST: $35.00 . . . No down time . . . No lost oil.

WHAT IT SAVED: Down time, one day = 14 barrels of oil . . . Tank cleaning bill . . . 56 barrels of oil recovered from paraffin . . . Estimated saving: $236.80.

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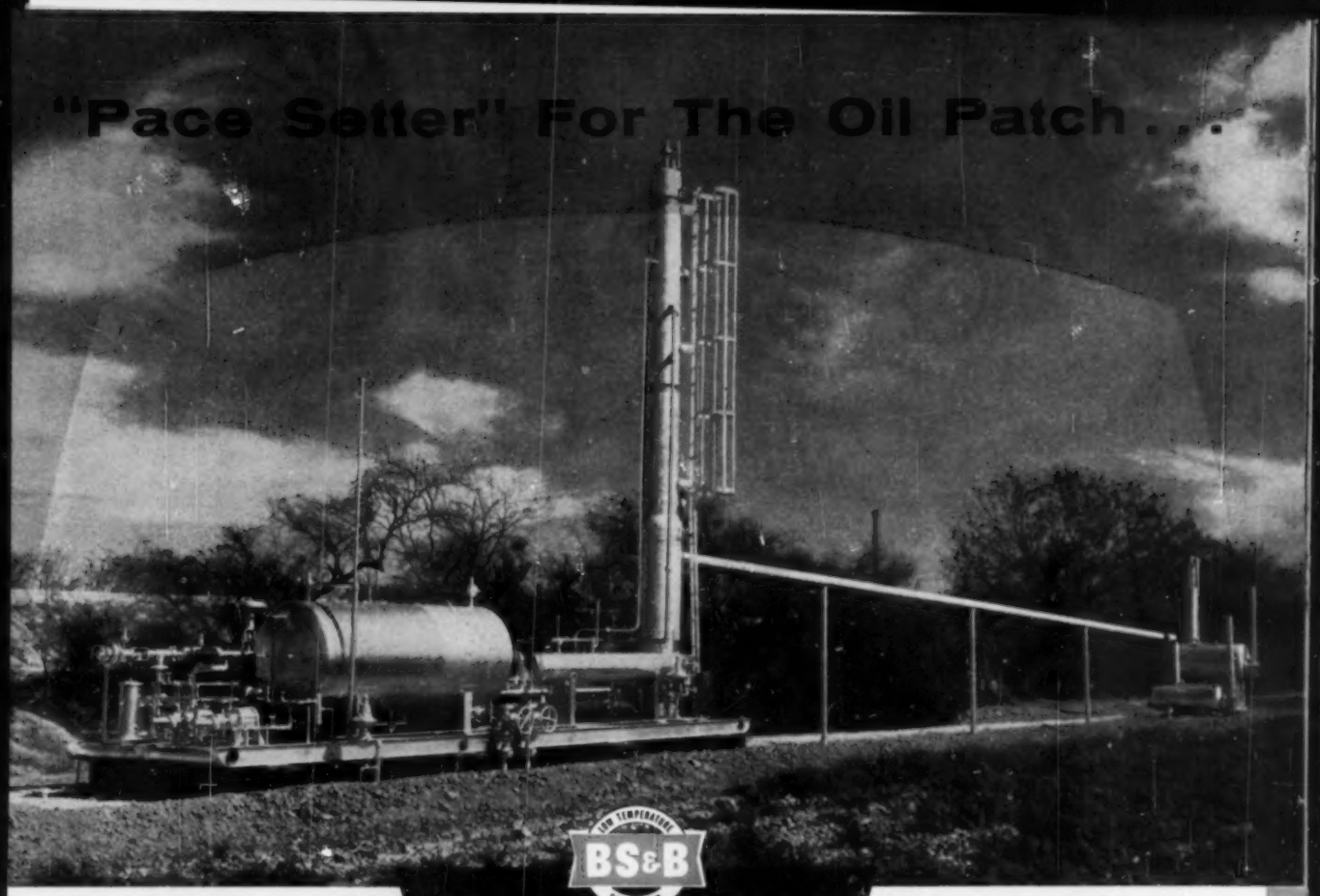

The BS&B Model GDH COLD-FRAC SYSTEM With Hydrate Inhibitor

BS&B "COLD-FRAC" Units with hydrate inhibitor (Model GDH) were especially developed for gas-condensate wells having an available pressure drop of 500 psi or greater, where gas dehydration and hydrocarbon dew point control present a problem.

The outstandingly successful performance of these Model GDH units in producing a maximum volume of condensate, and in dehydrating the processed gas to pipeline specifications, is due in part to the fact that each unit is specifically engineered to fit the conditions at the lease where it is to be operated.

If you are not now using a BS&B Model GDH "COLD-FRAC" Unit on your lease, why not talk it over with your BS&B Man? Or, send us the following information upon which to base our recommendation for a unit to efficiently handle your lease production:

1. Minimum inlet wellstream pressure and maximum inlet wellstream temperature.
2. Maximum wellstream flow rate.
3. A Podbielniak analysis of the wellstream (if available).
4. Liquid-Gas Ratio from welltest with test conditions.
5. Gas Transmission line pressure.
6. Desired Vapor pressure of stabilized condensate and storage pressure.
7. Presence of paraffin (cloud point of liquid from high pressure wellstream at wellhead flowing pressure and temperature).
8. Volume of salt water produced.

Basic Components of the Model GDH Unit to Separate End Products Include:

1. Inlet Liquid Knockout
2. Secondary Liquid Knockout
3. Cold Liquid-Gas Separator With Inlet Choke
4. Stabilizer

Auxiliary Components Include:

1. Wellstream Cooler
2. Product Cooler
3. Glycol Pump
4. Glycol Regenerator
5. Glycol-Oil Separator
6. Hydrate Catcher With Pressure Controller for Safety Shut-In

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4 VIEWS of Natural Gas Legislation

A Federal Power Commissioner, a transporter, a distributor and a producer presented their cases in a gas panel at the annual meeting of Texas Independent Producers and Royalty Owners Association, Galveston, Texas, May 20, 1957.

1. FPC Viewpoint

William R. Connole

Although the youngest man ever to serve on a Federal regulatory agency, Federal Power Commissioner William R. Connole made a clear presentation of the Federal Power Commission's viewpoint. His outlook is from the legal and regulatory side of natural gas problem. He feels Federal control is a natural result of increased use of natural gas.

During the time Connole was at Georgetown University and after he received his law degree, he served as legal assistant to Interstate Commerce Commissioner Walter M. W. Splawn. From 1950 to 1955 he was Counsel to and Chief Legal Officer of Connecticut Public Utilities Commission.

During World War II he served as meterologist in the Army Air Force. He is a member of Bar of Supreme Court of Errors of Connecticut, U. S. Court of Appeals, etc.

2. Pipeliners Viewpoint

Joseph J. Hedrick

To represent transmission companies Joseph J. Hedrick was chosen. He has been in the gas industry since 1917, when he began work for the old Empire Gas and Fuel Company. He is president and general manager of Natural Gas Pipeline Company of America, Texas Illinois Natural Gas Pipeline, Natural Gas Storage of Illinois, Texoma Production and Peoples Production.

An important man in his industry, he is president of Independent Natural Gas Association of America; director of American Gas Association; member of National Petroleum Council, Gas Industry Advisory Council, etc.

He received a law degree from LaSalle University. In 1930 he joined National Gas Pipeline.

Hedrick has the judicial approach needed to understand the two industries at each end of the long lines.

3. Gas Utilities Viewpoint

John E. Heyke

The president and chairman of the board of Brooklyn Union Gas Company was an excellent representative for the gas utility viewpoint. Not only has John E. Heyke 30 years' experience with a gas distribution company but he had the unique job of being chairman of the Council of Local Gas Companies, set up in 1956 to fight the Harris-Fulbright Bill. He knows the problems of utilities; says they are mistakenly termed "monopolies."

Heyke joined Brooklyn Union in 1933 upon graduation from Yale University.

A recognized leader in the utility industry Heyke is director of American Gas Association, trustee of Institute of Gas Technology, member of Gas Industry Advisory Council of Petroleum Administration for Defense.

4. Producers Viewpoint

Arch H. Rowan

TIPRO selected Arch H. Rowan to represent the gas producers on the panel. Rowan's long experience began in 1919 when he went to work as a roughneck in Goose Creek field. From a single steam rig in 1923 were developed Rowan Drilling Company and Rowan Oil Company, large concerns with widespread oil and gas operations. In his discussion, Rowan reveals his wide knowledge of the drilling and producing industry.

In World War I Arch Rowan served with the Marines as a sergeant major. As so many industry leaders do, he serves in many organizations. He helped organize American Association of Oilwell Drilling Contractors; is a director of TIPRO and IPAA. He has received Texas Mid-Continent's Distinguished Service Award and was named Chief Roughneck for 1957.

"The fact of life we both must face is the fact of Federal regulation . . . You take your place among a select number of industries of great critical importance. The nation can't get along without you. With this privileged position, however, comes a corresponding obligation. You have become subject to the fact of public regulation."

1.

Measuring the Fourth Dimension

William R. Connole

WHEN we studied geometry in high school we learned certain axioms that were basic to all the propositions that would follow. These were not subject to rigorous proof. The truth in them if not evident was assumed. No one questioned them. One of them was, "The whole is equal to the sum of its parts."

Never have I doubted this nor found reason to quarrel with the results reached in reasoning from it—provided the discussion was confined to the material order; that is, it dealt with things.

Once in a while, however, application of this proposition to situations in real life discloses that in the realm of human relations matters are not quite so simple. No one has learned how to apply a slide rule or a log table to solve the human equation. The axiom that the whole of human relations is equal to no more than the sum of the individuals cannot be demonstrated. Indeed, it had best not be assumed.

This discussion provides an example. We have the several points of view of individual components of this complex called the gas industry. One could properly expect that if all were put together a pretty good idea of the industry would be had. In other words, we could expect the industry to be no greater than the sum of its parts.

But is that so? Or do not the forces governing each segment reinforce each other as they combine so that a new and different structure emerges? I believe this is the case and that the result is greater than the sum of all the parts.

Affects Public Interest

This combination of producer, transporter and distributor results in one of the truly great industries in this nation. In fact, because of the nation's vital stake in your combined industry it has become more than an industry, it has developed into an institution. To use a famous phrase, your industry has now become one "affected with the public interest."

By the very act of becoming so essential, it has become more than three big industries combined into one. That is why I maintain the whole of the natural gas industry adds up to more than the sum of its parts. Moreover, I respectfully submit to you that this influence extends to all segments of the industry. To understand why I make this statement, may we consider for a moment the status now occupied by the industry.

It is well known that some 26 percent of the energy requirements of this country are provided by natural gas. The eclipse of manufactured gas as a source of energy is almost complete in this country. But this has been a very recent development.

During the many years before gas reached its present popularity producers were busy with their own problems without much concern for those of the distant large volume consumer areas. Today, however, no producer can close his eyes to problems of pipeline or distributor or consumer.

Modern technological developments which made possible the long distance transmission of natural gas were responsible for this change. In the brief period since 1942, the Federal Power Commission has authorized 69,000 miles of pipeline and 4,600,000 hp compressor capacity, costing altogether some $5.3 billion.

Due to the explosive manner in which this expansion has taken place, and to the hundreds, often thousands, of miles of pipeline which separate the producer from the distributor or the user, necessary contact between producer and distributor was for a long time obscured. Only lately has the contact between them become close and clearly evident.

Association Tightened

It was logical therefore that only with difficulty did the producing segment of the industry appreciate the intimacy of its association with the ultimate consumer of natural gas. It was logical for misunderstandings to grow up between such new found and, lately, intimate colleagues.

Yet, however the situation developed or whatever might have happened had other conditions obtained, producers' facilities are now attached to the kitchen ranges, to the basement space heaters and to the industrial furnaces of most of America. They are attached physically.

They are also attached in an intangible, but equally close association, for they have become an essential part of the gas distributing business. For that reason, I maintain that the producing business, together with the other segments of the natural gas industry, is directly affected with the same public interest that affects the entire industry.

Certain significant consequences flow from this state of affairs. Most importantly, in the nature of things a business affected with a public interest in this manner must move in the direction of the public interest *at all times*. To understand why it is a problem to attain an assurance that it will, let us consider, for a moment, some basic ideas.

Profit "Maximized"

Our society is a free society. It is an economy in which men are free to fail as well as to succeed; in which the motive of profit, profit for individual owners, is a strong force.

Now profit, Gentlemen, is not without honor.

Naturally, interests represented by various segments of any industry will try to make the most of the opportunities the economy affords them. As the economists might put it, they will try to "maximize their profits." There is no cause for concern in this state of affairs. Rather, it is a condition beneficial both to the businessman and to his customers. To the extent that your industry owes its remarkable expansion to the profit motive, we are indeed delighted to recognize the presence of the desire for profit in it.

The profit motive, however, must be weighed against the two other unique and fundamental characteristics of your industry. First, you are dealing with a precious, expendable and irreplaceable natural resource. Secondly, as we have

TURN TO PAGE E-10

TIPRO GAS PANEL

"Passage of legislation which removes the producer's facilities from Federal regulation will greatly relieve the Federal Power Commission work load, and this relief, undoubtedly, will shorten the period of time necessary to process pipeline certificate applications and rate cases."

2.

Transporter Surveys the Issues

Joseph J. Hedrick

TRANSMISSION companies in the natural gas industry have problems of markets, load factors, competitive price, expansion of facilities, financing of expansion, and, of course, supply—just as any organization has.

Unlike most other industries, the natural gas industry has not yet been able to completely satisfy the unusual demands placed upon it by our expanding, energy-consuming economy. As population was increasing about 14 percent in the last 10 years, marketed production of natural gas doubled.

Competitive Price

Small wonder that it did too, since the natural gas consumer used the ideal fuel at a lesser cost than had he used a competitive fuel. A few examples of comparative fuel costs for heating the average home in the 1956 season will explain the trend toward gas.

Cities	Fuel costs for heating average home 1956 heating season Gas	Oil	Coal
Los Angeles . .	$ 45	$ 60	$ —
St. Paul	173	204	185
Houston	29	56	66
Chicago	158	202	171
New York . . .	165	184	182

Under such favorable cost conditions it is not surprising that it is forecast that the trend toward greater utilization of natural gas in preference to other fuels will continue into the future. Natural gas now provides 46 percent of the nation's energy requirements for which it is competitive; it is expected to contribute 60 percent of those requirements by 1975. This increase indicates it will be necessary to double present production by 1975 to meet the 22.5 trillion cubic feet demand placed upon us by an economy supporting an additional 40 percent population.

Future Demands

You may not consider such estimates of future demands as optimistic speculation, but natural gas is chosen as the fuel for new housing construction in the majority of cases; in fact, in Philadelphia it is reported such choice is running 97 percent. In other areas the choice may approach that figure but the service may not be available until completion of pipeline and distribution facilities are constructed to handle the load.

In many instances the home builder is temporarily using liquefied petroleum gas rather than using another fuel in anticipation of later securing natural gas for heating. This year utilities are serving natural gas for 16 million house-heating customers, and by 1960 it is estimated there will be 21 million such customers.

Such demands are mixed blessings to the pipeline organizations because house-heating service sets the peak deliveries for which the pipelines have to provide delivery facilities. Having utilized those facilities on the coldest day of the year, house-heat service requirements begin to taper off, until they drop to practically nothing by summertime. Actually only 25 percent of pipeline capacity is used for this service in the colder northern areas.

Expansion of pipeline and distribution facilities to serve such requirements pose serious economic problems for the industry; 25 percent load factors do not justify nor can they support the investments required to construct the necessary pipelines and related facilities. Recognizing full well the serious problems involved, pipelines look forward to the challenge of meeting those enormous demands.

Underground Storage

Historically, one solution toward keeping a pipeline operating at full flow has been to start delivery of gas to underground storage near the consuming market area, when house-heating requirements began to drop off. By so doing, pipelines were able to operate at a high degree of efficiency, and this efficiency resulted in low unit-operating cost. This delivery into storage also made it unnecessary (to the extent of the usable storage deliverability) to provide pipelines from the production field to the market area in size adequate to meet peak requirements. This decreased investment costs.

Unfortunately, use of such facilities until comparatively recently has been limited to those market areas near depleted oil or gas fields. In the last few years pipelines and distributors not so fortunately located have aggressively searched for geological formations in their market areas. When these are capable of receiving, holding, and delivering natural gas they help maintain natural gas at a price level competitive with other fuels in the area they serve. Some organizations have been so fortunate as to find such natural reservoirs, and vigorous development of these facilities has followed.

Volume of gas that can be stored is limited by the extent of the geological formation used, whether it be a depleted oil or gas field or otherwise. So the search for bigger and better, and even for smaller fields, goes on.

There were 178 such storage pools at the beginning of 1956 with ultimate storage capacity of 2.1 trillion cu ft of natural gas. During the year, 10 additional projects were started which will add another 82 billion cu ft of capacity. As of December 31, 1956 there were 1.5 trillion cu ft of natural gas in underground storage and the volume is increasing annually.

Sixty-one million dollars were spent in 1956 on underground storage projects, bringing the total investment for such purposes to date to about $456 million. Another $600 million is expected to be spent for such facilities in the next 10 years. Of greater importance though is the service they have rendered.

Storage Delivery

The peak delivery of natural gas from underground storage during 1955 (1956 isn't yet available) was 6.5 billion cu ft, a volume equal to the capacity of eleven 30-in. pipelines operating at 850 lb. This volume of 6.5 billion cu ft is sufficient to serve about 4 million house-heating customers in most of our northern areas. This indicates that at least 25 percent of the house-

TURN TO PAGE E-11

TIPRO GAS PANEL

"Perhaps the most widespread misconception of the gas distributing business is that companies in this field operate as protected monopolies. This is far from the truth. The only protection from our exclusive franchise is that another gas company cannot come into our territory and lay pipes to provide gas service."

3.

What the Gas Distributor Sees

John E. Heyke

PRIOR to our appearances before the House and Senate Committees on Interstate and Foreign Commerce, I am reasonably sure that few here had ever heard of The Brooklyn Union Gas Company.

I realize that, in all probability, I was invited here to represent the gas distributing segment of the industry, or, more accurately, representing those gas distributors who opposed passage of the Harris-Fulbright Bill and who now, in one degree or another, are prepared to support the compromise on which a number of us have spent many long hours.

There is a group of companies who opposed the Harris-Fulbright Bill and who are prepared to oppose the new Harris Bill. This group (I am happy to say) seems to be very much in the minority, at least as far as size and the number of customers they serve. I am ready to assume, however, that they will not be quiet in their opposition. It is a safe assumption that they will not hesitate to speak out and that their voices will be loud and their opposition will be clear.

I am here, of course, representing only Brooklyn Union, but because of my activities, first as Chairman of the Council of Local Gas Companies, and second as a member of the small group who hammered out this compromise, I think what I have to say is fairly representative of the thinking of most distributors *except* those in opposition to this compromise legislation.

Began in 1825

Brooklyn Union Gas Company is a straight gas-distributing utility operating entirely within the city of New York. It is the product of combinations of 23 smaller companies, the first of which was incorporated in 1825. The company and its predecessors have been continuously in the business of providing gas service since 1849—a record of uninterrupted operation extending over 108 years.

Brooklyn Union serves an area of 175 square miles containing a population of 3,600,000. This is in startling contrast to the situation here in Texas which has a population of about 8,000,000 in an area of 267,000 square miles. The company has 1,020,000 active meters, a gross plant investment of $155,000,000 and total gross revenues of about $70,000,000 per year. Net income is slightly over $6,000,000.

Development History

Typical of most old line gas-distributing companies, Brooklyn Union through its constituent companies came into being as a supplier of lighting. As gas lighting gave way to electricity, the major source of our business shifted to cooking, to which were subsequently added water heating, space heating, refrigeration, industrial uses, and central heating.

Until 1952, the major source of gas was from our own production plants. Initially, coal was the primary raw material for gas production. After the turn of the century, most of our gas was made from oil in the water gas process.

Contrary to some opinion, the changeover from manufactured to natural gas is not a simple operation for a distributing company. In the case of Brooklyn Union, total cost of conversion was approximately $29,000,000 consisting of about $25,000,000 for the cost of converting 2,300,000 gas appliances and about $5,000,000 for plant write-offs net of taxes.

In addition to the cost, conversion required extensive engineering planning for several years prior to the actual changeover. It was necessary to sectionalize almost 2900 miles of distribution mains, redesign production plants to produce a high Btu gas as an emergency or peak load substitute for natural gas, and finally make provision for a specialist group of 3000 conversion mechanics who completed the changeover in a 6-month period. Meticulous planning was a hard necessity because a slight miscalculation could have been disastrous in the densely populated area we serve.

Since 1952 we have depended almost entirely upon natural gas and have converted our two former water gas plants to oil gas production for peak day and emergency use. We also maintain some propane storage for emergency use.

Brooklyn Union's Job

As a public utility, the company has been subject to regulation by New York Public Service Commission since 1907. Regulation in New York may properly be characterized as strict and quite comprehensive. For example, the Commission has jurisdiction over:

(1) The system of accounting, (2) rates, (3) financing, (4) franchises, and (5) quality and safety of service.

Contrary to some opinions, the company does not operate under a guarantee that it will receive a specified minimum return on its investment. It does operate with the certainty that if return begins to exceed 6 percent it will be required by the Commission to make a convincing showing that rates should not be reduced.

Also, the Commission has taken the position that public utilities subject to its jurisdiction have a primary responsibility to meet all demands for service and must do so even if the consequences lead to inadequate earnings or even financial reorganization.

Even though regulated, we are no different from other privately owned businesses and must produce earnings and dividends to keep our stockholders happy, and further develop a satisfactory picture of financial health so we can obtain capital at a reasonable cost.

Perhaps the most widespread misconception of the gas distributing business is the idea that companies in this field operate as protected monopolies. In our case, this is far from the truth. The only protection we obtain from our exclusive franchise is that another gas company cannot come into our territory and lay pipes to provide gas service. We engage in stiff competition for every form of fuel utilization. In a practical sense, electric and water companies are true monopolies to the degree that alternatives are not available

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Utility-type regulation "in many instances sets a price of gas in excess of what you can sell it for. In other fields the price thus determined is far below the price you have contracted to sell it for, and below the reasonable market price. . . . This method wholly ignores the sanctity of a contract."

4.

Gas Producer Pinpoints Problems

Arch H. Rowan

THERE is one premise with which I think all can agree, and that is the potential consumer demand for natural gas is far from satisfied. Evidence abounds to indicate that the scope of the market is limited only by the supplies and facilties. Consumers are ready and willing to pay a price to provide the facilities and services necessary to make natural gas available. It is the maintenance of present supplies and the assurance of future supplies of natural gas that is of paramount importance to the consuming public.

Certainly pipeline and distributing companies are equally dependent upon the continuity of supply of this exhaustible and irreplaceable natural resource. Likewise, the Federal Power Commission, if it is to protect the public, must develop a regulatory pattern which will not only permit but encourage the producer to carry on the hazardous business of finding and developing new supplies of natural gas.

If the producer is to stay in the gas business, he must continually find and develop new gas to replace the gas currently being sold. Because of the increasing depths to which he must drill and because of the increasing cost of new reserves necessary for him to maintain his deliveries, his replacement costs of reserves are much greater than the cost of his depleted reserves. Unless the producer is permitted a sufficient amount of income or cash flow to plow back into the search for natural gas, he is operating on a liquidating basis which will eventually force him out of the gas business.

Crude Oil vs Gas Reserves

The liklihood of our running short of crude oil supplies in the foreseeable future has been lessened because of the tremendous potential for crude that is contained in the oil shales and tar sands. With the constant improvement in the methods of secondary recovery operations, it now seems likely that we will be able to add substantially to our reserves from this source.

It is most significant to the gas consumers, the gas distributors, and the gas pipeline companies that these sources for crude oil reserves will not add one cubic foot to our gas reserves. It is clear, therefore, that exploration and development of natural gas reserves must proceed diligently and at a rapid pace if our current and future gas consumers are to be serviced.

During the 10-year period ending in 1955, total United States gas reserves have increased from 147.8 to 223.7 trillion cu ft. During the same period, natural gas production rose from 4.9 to 10.1 trillion cu ft, and marketed gas increased from 4.0 to 9.4 trillion cu ft.

Notwithstanding continued growth of proved gas reserves, the enormous demand for natural gas is exceeding our ability to find it. Based upon the present proved gas reserves and the 1955 gas demand of the United States, reserves are only 22 times the annual production rate, whereas 10 years ago reserves were 33 times the annual production rate. In other words, assuming that the gas demand did not increase over the 1955 figure, present proved gas reserves in the United States would last only 22 years.

Taking deliverability into account, and assuming no increase in demand and no additions to reserves, present demand could only be supplied for 14 years. The fact is, however, estimated demand by 1965 will require an annual production rate of approximately 15 trillion cu ft, and with no additions to reserves, the breaking point interim would be 11 years.

Gas Must Be Found

There has been a widespread popular belief that in the search for oil sufficient quantities of natural gas can be uncovered to satisfy the consumer market. Such an assumption has *misled* people to believe that the finding costs for oil could largely carry the costs for finding natural gas. In the early days of the business when there were relatively few, if any, markets for gas, perhaps this was true. Since that time, however, we have gone from surplus to shortage. Gas must now bear its fair share of the load of exploration and development, if the producer is to keep up the hunt.

In this connection, there are definite indications that most of the shallow oil and gas reservoirs have been found. This is borne out by the fact that present gas supplies have shifted from dry gas sources to casinghead and condensate gas sources.

During the past 11 years total volume of gas marketed from dry gas wells decreased from 66 percent to 43 percent of the total. In the same period, marketed gas from casinghead and condensate gas wells combined increased from a low of 34 to the present 57 percent. Increasing amounts of gas condensate and casinghead gas production can be attributed to deeper drilling. Average ratio of casinghead gas to oil in oil wells increases with depth at a very rapid rate.

When we encounter an oil and casinghead gas reservoir at a considerable depth, we may expect to get only about one-third as much crude oil as we would get in a reservoir of comparable size at a shallower depth. The amount of casinghead gas produced from shallow oil wells is so low that the producer has barely enough gas to operate a lease. The gas condensate well is a phenomenon which occurs only at great depths. Practically none occurs above 6000 ft. This simply means that if the producer is to be expected to undertake this deep drilling from which we are now getting more and more of our future gas supplies, he will have to depend upon the price of gas—and not oil—to compensate him for his efforts.

Discoveries Smaller

Exploratory drilling over the past 10 years has increased over 2½ times, while total investment in oil and gas-producing facilities has increased threefold. In spite of the large increase in exploratory drilling, the percentage of successful wells has not changed during this same period. Generally, ratio of successfull drilling has been one out of nine, notwithstanding improved technological advances made in the

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TIPRO GAS PANEL

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CLARK BROS. CO., Olean, New York—Gas turbines, engines, and reciprocating, centrifugal and axial flow compressors — gas, steam, electric and diesel driven.

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GUIBERSON

THE GUIBERSON CORPORATION, Dallas, Tex. — Swabs, packers, anchors, workover equipment — drilling heads, blowout preventers, tubing blocks, hooks, swivels, kellys, savers, unions. Gas lift equipment. Molded rubber products.

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LANE-WELLS CO., Los Angeles, Calif., Houston, Tex., Oklahoma City, Okla.—Electric and Radioactivity Well Logging. Kone shot* perforating, bullet perforating, packers, bridging plugs.

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PACIFIC PUMPS, INC., Huntington Park, Calif. — Centrifugal pumps for refineries, power stations, pipelines, and chemical plants; plunger pumps for oilwells.

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ROOTS-CONNERSVILLE BLOWER DIVISION, Connersville, Ind.—Rotary positive blowers, gas pumps, centrifugal blowers, exhausters, vacuum pumps, and positive displacement meters.

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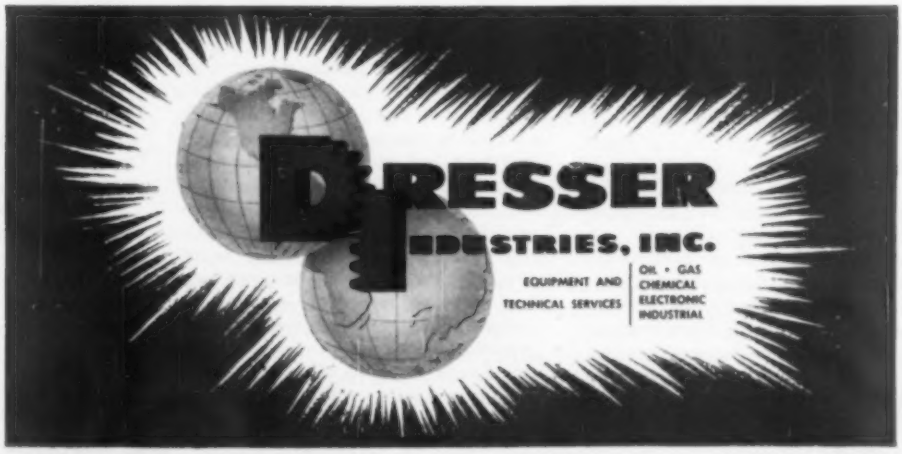

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FPC Viewpoint

CONTINUED FROM PAGE E-4

just seen, the need for that resource is so great that its use has become a vital part of the very existence of the people whom you serve.

The resolution of the problem under collective or totalitarian systems is sought through Government ownership. One form or another of Socialism. In this country, thank God, we reject this empty concept.

Public Restraint

But the problem can scarcely be left to chance for its solution. This was tried in the early days of our history. Experience then proved what might have been expected. There were too many irreconcilable points of view.

In this country we solved the problem otherwise. We permitted essential industries to remain in private hands while exercising the needed degree of public restraint and direction. This was done by means of agencies set up for that sole purpose. These agencies are creatures of, and responsible to, the elected representatives of the people—the Legislatures and Congresses. They are independent of the Executive Branch of the Government.

One of the noblest achievements in the political economy of this nation is the successful use of this regulatory form. Independent of the Executive Branch of our Government, it resolves the give and take between private and public interests which inevitably occurs from time to time in essential industries; even in the gas industry.

I recently observed a remark of one of the most popular students of the American system of Government, Mr. Sidney Hyman, author of *The American President*, writing in the *Washington Post* and discussing the power of regulatory Commissions. He states: "Indeed, that power is so vast as to warrant this passing suggestion: That it is not the President, the Congress or the Supreme Court making the hourly decisions which count the most in the day-to-day life of Americans. It is the regulatory agencies which do."

Protects Against Socialism

I have had intimate personal experience in two important Federal regulatory agencies and in a very active and respected State regulatory commission. I have served at all operating levels, from obscure clerk to agency head. From these experiences, I conclude that the concept of the regulated public service industry is among the firmest bulwarks built into our economy for protection against Socialism attacks.

It is not without significance that in the United States alone of all nations there exists a railroad industry still remaining in the ownership of private individuals. It is no accident that only in this country is there an effective railroad regulatory agency.

In our nation we have determined that the entire interstate natural gas industry shall be regulated in the public interest by the Federal Power Commission. I appreciate that your organization (TIPRO) disapproves. Though we may as individuals feel thus, the situation is apparently going to persist in this form for some time to come.

It is within the realm of possibility that the working of competition and other forces may provide the opportunity to promote your own interests without adversely affecting others. Many wise and informed men claim this to be true.

But this question, I think, had better be discussed at another place and time. The fact of life we both must face is the fact of Federal regulation.

Fourth Dimension

You will be given a thorough and impartial analysis of the way this gas business measures up from the point of view of a producer, a transporter, a distributor. Under existing conditions, as I have discussed them, the Federal Power Commission must consider these three dimensions at once. As I have tried to develop, there is also a fourth dimension of which the Commission always must be aware and hope the industry is conscious of it too. That is the dimension which measures the extent of the public interest.

Once you understand this responsibility and appreciate it fully I feel certain much of the misunderstanding with which you might view some of the actions taken by the Commission will disappear.

There is an old saying in the regulatory business that one reliable way of testing the wisdom of the position being taken on any given matter is to count the bricks being tossed from the directions of the parties whose views you are attempting to reconcile. If there are about as many from one direction as another, the chances are the decision is close to accurate. Please believe me, being pelted from all four directions of this business at once sometimes becomes something less than comfortable.

I have told you why, in my understanding, the producing industry now occupies a position where it can be operated no longer exclusively for the personal and private profits of its owners. I have indicated why I feel that it is now an industry affected with the public interest to the same extent that the other segments of the natural gas industry have been for some time. It remains only to indicate what the Commission proposes to do and what basic principles will motivate the action it takes. This can be done quite simply.

FPC Position

The Federal Power Commission is organized for and dedicated to the purpose of assuring that whatever steps the interstate natural gas industry takes, there will be reasonable assurance that the public convenience and necessity will benefit from them. No punitive measures are contemplated by the FPC. No motives of personal gain prompt the opinions or actions of the Commission. We have no inclination or jurisdiction to promote any one segment of the industry over any other or to emphasize one aspect of the business to the detriment of the other. Ours is the broadest possible responsibility. We are keepers of none but the public trust.

I have purposely described the regulatory agency in rather favorable terms. Do not for a moment, however, believe that I have overlooked the weaknesses to be found in this system. Systems, being man made, are not immune to criticism. None is beyond improvement.

The strength and quality of the regulated public service concept resides in three of its fundamental elements.

1. Organic statute creating the agency;
2. Personnel making it up;
3. A vague thing called "regulatory climate."

Organic statutes can be amended, corrected or even repealed as conditions require. For this radical type of surgery this country must depend on the skill and wisdom of its political physicians, the Legislatures and Congresses.

The integrity and intelligence of agency and staff members depend on the judgment of those who appoint, those who confirm, and those who hire them. And at this point I cannot neglect the opportunity of commenting on the largely unappreciated and nearly incredible dedication which characterizes virtually all the people who are engaged, at Governmental levels, in this great business of regulation. This despite a quite inadequate scale of wages.

For example, I have been advised by one engineering staff member of an administrative agency that of all of the members of his class in engineering school only one man is paid at a lower rate than he. That man is in San Quentin.

Finally, the vague thing called "regulatory climate" is the most treacherous.

delicate and sensitive of the three. Does the Commission desire to punish? To stifle? Or rather does it want to encourage where needed, reward where deserved, understand at all times the problems of the industry?

Which one it shall do depends to a larger degree on regulatory climate than on any other factor. Speaking for your Federal Power Commission, you can rely upon the type of constructive, realistic, progressive regulation in the public interest that you want and require.

In conclusion and summary I would suggest to you Gentlemen that you should be flattered — complimented — satisfied with your industry's success. You take your place among a select number of industries of great critical importance. The nation can't get along without you. With this privileged position, however, comes a corresponding obligation. You have become subject to the fact of public regulation.

I can assure you, once again, of the intensity and sincerity of the interest your Federal Power Commission has in the problems of your industry. I would urge upon you once again that you recognize the difficult task of the Commission in reconciling the inevitable differences between segments of the natural gas industry. I would ask you once more to remind yourselves that your business is unique in many respects. By its very nature your industry requires informed, enlightened direction in all its segments.

As an essential institution the combined gas industry is, indeed, more than the sum of all its parts. If we all—companies, customers and Commission—join in directing the industry to our mutual benefit, the very essentiality that distinguishes the combination from all others can be turned to improve the well-being of all segments of the economy.

If, on the other hand, we come to loggerheads with each other, it may well be the undoing of us all. I have confidence in what direction you will move. Your faith in us is secure.

Pipeliners Viewpoint

CONTINUED FROM PAGE E-5

heating customers are enjoying gas heat as a result of service rendered by underground storage of natural gas. These customers, as well as all customers, domestic and industrial, are benefiting by lower gas rates as a result of the enterprising efforts of pipelines and distributors who supply this service.

Off-Peak Sales

Underground storage facilities, however, are only able to absorb a portion of the valley gas and the pipelines with the distributors' help must look to two other levelers of load factors, namely, the firm industrial and off-peak industrial sales, in order to keep gas rates at a level competitive with other fuels.

Essential to industrial natural gas sales, just as with domestic sales, is price at a competitive level with other fuels. Fortunately for the gas industry, the same economic factors which are increasing gas rates are increasing the price of other fuels at the same time. But only so long as gas remains competitive can the gas industry be assured of the potential market I have discussed. The advantageous price margin between gas and other fuels which we have enjoyed in the past is narrowing, and in some instances is in favor of the competing fuel.

Off-peak industrial gas is probably the most competitive fuel market entered by the gas industry. It is also a most essential market for the pipeline load factor since all gas used is valley gas. In this type service, the steam-generating plant is one of the largest consumers. Because such buyers are big consumers, they are in an unusual bargaining position in the purchase of their fuel requirements.

Margin between price of gas and coal for such purpose, of course, varies considerably in different sections of the country. Within any specific section it is affected by proximity of coal fields, advantageous transportation facilities, and by the type, heating value, quality, and form of the coal available.

Since this market is of such an individual character, I believe it advisable to discuss an instance of which I am particularly aware. This instance is merely illustrative of a problem confronting other pipelines too.

The Case of the Uncertain Customer

One of our distributors serves a steam-generating plant with annual requirements equivalent to 18 billion cu ft of gas. Currently, this distributor is delivering to the plant at the rate of 4 billion cu ft annually. At another time it delivered about 50 percent of the plant requirements. Twice in the past few years the distributor lost the load completely, when the plant operator believed it to his advantage to operate with coal.

Once it lost the load when this gas was priced at 25.2 cents per Mcf and regained it at a price of 23.7 cents, only to lose when a utility sales tax increased the effective price to 25 cents and then to regain it at 24 cents, tax included.

I can assure you, the distributor's pencil was plenty sharp in determining the minimum rate at which gas could be sold, both when it lost the load and regained it.

It could be that some might feel that domestic rates could be increased since the spread between gas and other fuels is greater for that service, thereby permitting reduction of industrial gas rates. This, however, is impossible since regulative bodies which control pipelines and distributors hold that each type service must pay its own way.

Without adequate industrial firm or industrial off-peak sales, the pipelines cannot maintain high enough operating load factors to support the anticipated expansion programs.

Distributors Load Important

Importance to the pipeline of continued growth of the distributors' base load cannot be overemphasized. This load based on fuel for cooking, refrigeration, hot water heating, and clothes drying is our bread and butter load.

Electric competitors are waging aggressive advertising and promotional programs to get this load away from gas. We are still in front in the battle for this service, but where we sold two gas ranges for every one electric in the period from 1946 to 1955, during the year 1956 the ratio dropped to 1.6 gas to 1 electric. In certain areas we are, however, doing better, such as the 9-to-1 ratio now prevailing in Chicago.

Such statistics indicate we have a selling job to do and our national television program, Playhouse 90, on each Thursday night, is one of the programs designed to keep gas in front.

So long as reasonable market price for gas prevails, the pipelines are assured of these markets. Other problems, however, delay immediate fulfillment of our desire and responsibility to supply those markets.

Expansion Problems

Large diameter pipe, essential for pipeline expansion programs, is in tight supply; other material and equipment is in relatively easy supply. The capacity of major pipe mills is presently committed under firm orders into 1961. This delay has, of course, been to some extent anticipated, and expansion programs are in many instances projected well into the future.

Construction costs are high and continue to increase. Currently, they are running about 186 percent more than they did in 1941.

Long-term money is tight and costly. Interest rates are at the highest level they have been for years. It appears

TIPRO GAS PANEL

that they may have reached a plateau and that by year-end money will ease sufficiently for the pipeline industry to market securities under more favorable terms than are now possible.

I have discussed markets, price, material, construction, and money costs first, because the effect of these on our plans for the future lend themselves to statistical and economic analysis upon which we can rely.

Supply Needs

Supply, of course, can also be quantitatively measured, and it is encouraging to note that estimated known reserves are at an all time high of 237.8 trillion cu ft, a supply adequate for 21.9 years based on our present requirements. These known reserves, of course, are largely dedicated to serve present markets. Pipelines must of necessity look to future exploration and development of gas resources for proof of adequate supply to support applications for Federal Power Commission certificates authorizing construction of facilities to serve the expanded markets already discussed. Pipelines also must provide this proof in order to attract investment capital to construct these facilities.

Ordinarily, in financing a natural gas pipeline, debt money is borrowed for a term of 20 years and the debt amortized accordingly. Years ago, the lenders were satisfied with a geologist's opinion that, although the reserves of the pipeline were not sufficient to enable the debt to be paid off in that time, there were reserves in the area which by diligence might be acquired to service the debt through its life. In recent years, however, the lenders have tightened up and have required proof of reserves at least equal to the debt amortization, and more recently have required year-to-year adjustments in debt amortization.

Since adequate supply for these purposes is considered to be about a 20-year supply, pipelines are concerned with a problem which, we hope in part, is being resolved in Congress.

Legislation

Passage of legislation acceptable to all segments of the industry, which provides incentive for aggressive exploration and development of gas resources by producers and pipeliners, can, I am certain, lead to rapid discovery of vast unlocated reserves, which, it is believed, are twice as great as known reserves. Such discovery can remove uncertainties as to adequacy of supply, which has been a great problem to pipelines.

Passage of legislation which removes the producer's facilities from Federal regulation will greatly relieve the Federal Power Commission work load, and this relief, undoubtedly, will shorten the period of time necessary to process pipeline certificate applications and rate cases. This we would appreciate, and when I say it I imply no criticism toward the FPC for its members have struggled with a terrific work load these past years.

Pipelines have problems. They are solvable with the cooperation of all segments. We believe that the natural gas industry will meet the enormous demands placed upon it and, in so doing, will attain stature even greater than it enjoys today.

Utilities Viewpoint

CONTINUED FROM PAGE E-6

to the consumer. This is not so for gas service; the consumer can make a number of substitutes if he so desires.

Competitive Position

Keeping in mind that we have been selling gas in our territory for over 100 years, here are some figures taken from a recent survey which indicate our proportion of residential fuel market:

	% Gas	% Other fuels
Cooking	99%	1%
Water Heating . .	25	75
Refrigeration . .	12	88
Central Heating .	10	90

On the face of it, with the exception of cooking, this does not appear to be much of an accomplishment for more than a century's effort. I can say, however, that even this limited attainment has been obtained by hard-hitting and aggressive action.

We maintain a full-fledged sales department of 322 people who make use of every conceivable method of promoting gas sales. In 1956, for instance, our own direct sales of appliances exceeded $7,000,000. In addition, we assisted independent dealers and equipment manufacturers in selling gas equipment to our consumers.

We hear a great deal these days of the high costs of exploration and development in the gas-producing business. The costs of developing a market for gas in our territory are also high. In direct sales promotion, we spent close to $2,000,000 last year and an additional $1,800,000 in indirect promotion in the form of free appliance adjustment service. This combined figure approaching $4,000,000 is close to the annual average since the introduction of natural gas in Brooklyn.

I realize these numbers are perhaps not too impressive in Texas, but I think they take on significance when related to the estimated new load added in 1956 of 2,200,000 Mcf. In other words, we are spending approximately $2.00 in promotion for each 1000 cu ft of load added.

"Dry Holes" in the Market

We too run into a high percentage of "dry holes" in our market development. Most important source of sales prospects is from leads turned in by Brooklyn Union employees. In 1956, of 63,000 such leads, 5000 proved productive—a ratio of 12 to 1. We also do a considerable amount of rank wildcatting in the form of cold canvassing, or doorbell ringing. Although figures are not available, we know that the percentage of "hits" from this activity is very low.

We have been able to maintain up until now a dominant position in the home cooking market. This stems in part from the fact that almost 70 percent of our customers live in apartment houses where the selection of cooking equipment rests with the building owner. A very large proportion of these customers use nominal amounts of gas and detailed studies indicate that many are actually served at a loss.

The low indicated saturation of water heating is also influenced by the higher percentage of apartment house dwellers. In such buildings, water heating is supplied from a large central boiler using the heavier grades of oil or coal with which we cannot compete effectively at present rate levels. In the one and two-family market where we compete against No. 2 oil, we do show a fuel cost advantage, and our water heating saturation is over 50 percent.

As in the case of water heating, we cannot compete effectively with the heavy oil used for central heating in apartment houses. On an operating cost comparison, gas is now cheaper than oil in the one and two-family home market where our present saturation is 22 percent.

Rates Reduced

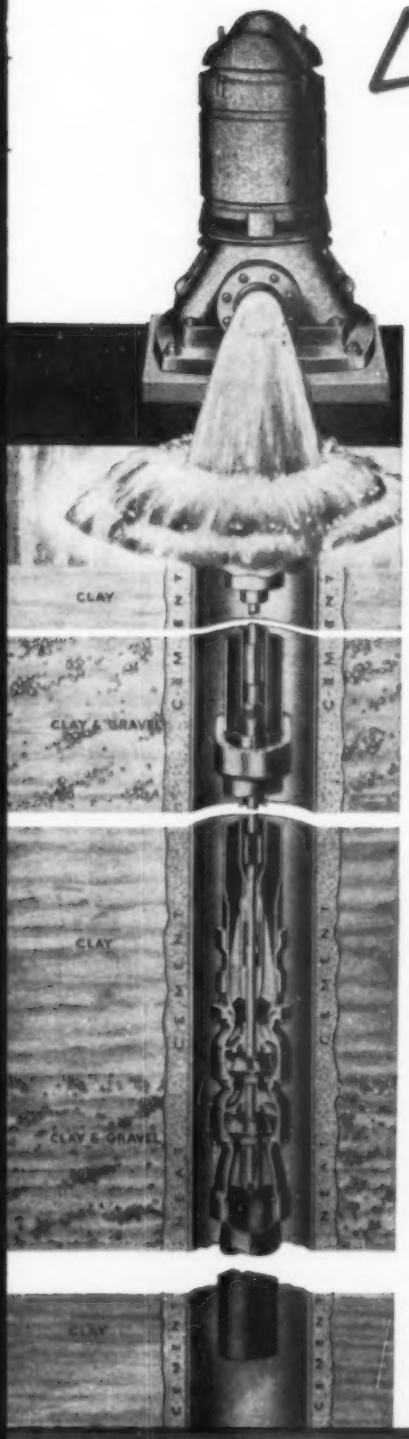
Since the changeover to natural gas, Brooklyn Union has made rate reductions totaling more than $4,000,000. Two fundamental factors made these reductions necessary:

1. Return limits imposed upon us by regulation.
2. Need to improve competitive position of gas, and thereby induce sales volume growth.

We feel we have met both problems as we have adjusted rates in accordance with our ideas, and we have been able to increase sales volume substan-

TIPRO GAS PANEL

Layne knows more about water bearing formations!



On whose say-so? Not on ours—but on the experience of scores of American and foreign firms and municipalities whose very existence and success depend on an adequate supply of water.

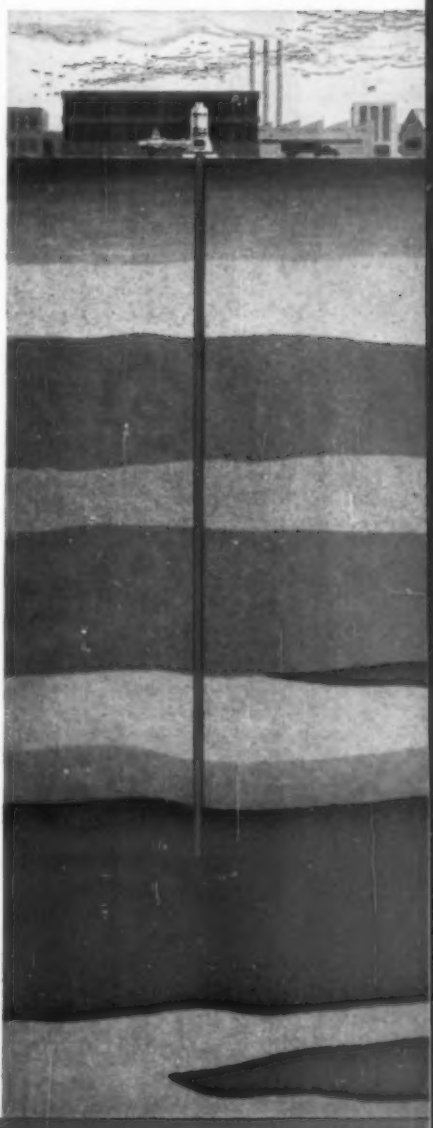
Knowing where the water is — and then tapping the subterranean source is but a part of the vast knowledge the Layne organizations have accumulated in three quarters of a century.

Once the source is determined and the water supply developed, a dependable means for delivering the water must be provided, and that's where the famous Layne pump comes in. For each Layne pump is specifically engineered for the particular job. There is no "stock" Layne pump. Your pump is created for your job —making use of the knowledge of strata, water requirements and usage.

ENGINEERED, DEPENDABLE PERFORMANCE IS WHAT YOU GET WHEN LAYNE DOES THE JOB— COMPLETE FROM WATER LOCATION TO YEAR AFTER YEAR OF TROUBLE-FREE PUMPING.

YOUR NEXT WELL AND PUMP INSTALLATION MAY BE MONTHS OFF. GET TO KNOW THE LAYNE FOLKS IN YOUR AREA. SAVE TIME AND MONEY THROUGH THEIR INTIMATE KNOWLEDGE OF WATER.

Send now for our general services bulletin No. 100.



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tially over the last four years.

I would like to take a moment here to comment on a point concerning which there has been considerable misunderstanding. This refers to the bewilderment of gas producers over the fact that the average cost of gas to the consumer in Brooklyn is $2.00 per Mcf as compared to field prices which are a fraction of that amount.

Over 55 percent of our customers are apartment house dwellers whose use of gas is small. For example, 25 percent of these apartment customers use 300 cu ft or less per month. While the usage of these consumers is nominal, the company must read the meters, render bills, service appliances and provide adequate facilities to meet their infrequent peak demands.

Detailed cost studies indicate the cost of being ready to supply these minimum use consumers is approximately $1.30 per month. Our rates provide that all customers must pay a minimum charge of $1.15 which includes an allowance of 300 cu ft of gas. From a customer using 300 cu ft we will receive $1.15 in revenue, which equates to an average rate per Mcf of $3.80. Our costs for supplying this customer are $1.30 plus 10 cents (300 cu ft at 35 cents per Mcf) or $1.40 which equates to an average cost per Mcf of $4.66.

Thus, with a relatively high percentage of small use customers whose average rate is high, the overall average is necessarily raised. Furthermore, we are not in business to lose money and, consequently, the costs of serving the small consumer which are not recovered must be spread to the rates for larger consumers. Hence, the house-heating customer whose average rate is close to $1.20 is bearing some share of the unrecovered costs of the apartment house consumer whose average rate is $3.80 per Mcf.

The "Hard Sell"

However, the mere fact we have been able to establish gas as the lowest cost fuel for heating a private home has not brought a flood of heating orders. Of one and two-family houses in our territory 65 percent are heated by oil. A majority of these installations were made since 1945. For the most part, these oil burners are providing satisfactory automatic heating service. Our problem is to convince the owner of the house to scrap a substantial investment of about $700 and spend an additional $700 for gas equipment.

Some idea of the magnitude of the problem can be seen if these figures are considered for the total market. If we are to replace oil completely in the 185,000 one and two-family houses presently so equipped, we are dealing with a total consumer investment of $130,000,000 which we must replace with a comparable outlay for new gas equipment.

Consequently, we are not in the fortunate position of having the customer pounding on our door. We are rather faced with the necessity of resorting to the "hard sell." We sincerely believe that gas has advantages over oil, other than cost, but these are not of much value in the consumer's mind. Hence, it is vital in our load growth plans that we maintain rates which clearly place gas at a lower cost than oil.

We are confident of our ability to gain dominance ultimately in the home-heating field, but this accomplishment poses some very large problems for us. We will require an enormous increase in gas supply. Certainly, a large proportion of our needs will be met with additional volumes of pipeline gas. It does not appear economically feasible to meet all of our requirements in this fashion as heating has a load factor of barely 25 percent. We must, therefore, consider all other possibilities, including local storage, propane storage, oil gas from our own plants, synthetic coal gas, and liquefaction of natural gas. We must build up off-peak and industrial loads in order to improve our overall load factor. We have to spend very large sums for reinforcement of our system.

Supply and Price

Key to successful solution of these problems is adequate supplies of natural gas at reasonable prices. Obviously, our interest in the producers of natural gas is direct and vital. Developments in natural gas production in the Southwest will definitely affect the development of the gas load in our territory. We are confident that Brooklyn Union is on the threshold of an enormous growth in gas sales.

By sincere mutual understanding of each other's problems we believe that the opening up of the vast New York market can be a real gold mine for the distributors, the pipelines and the producers. The fact that you have asked me here is encouraging evidence that you are convinced of the mutuality of our interests.

We are aware that you, too, have problems and that they must be adequately treated in any sound plan to realize the full potential of the New York market. Acting together, we have much to gain. If we act from motives of pure self-interest, we have much to lose. As intelligent representatives in our free enterprise system I am sure we will reach sensible compromises which will prove satisfactory to all.

Producers Viewpoint

CONTINUED FROM PAGE E-7

field of exploration. More significant is that size of the discoveries (barrels of oil and cubic feet of gas added per exploratory well) have been smaller almost every year, but average depth has been greater.

To supply the anticipated production rate of 15 trillion cu ft predicted for 1965, it is estimated that the discovery rate at that time will have to be 22.5 trillion cu ft per year, or approximately 50 percent more than the present discovery rate. Due to continually decreasing rate of discoveries per exploratory well, it is clear that in order to maintain this discovery rate, which is 50 percent higher than the present, rate of exploratory drilling will have to be increased substantially more than 50 percent.

Wells Deeper

Since Colonel Drake's well was drilled in 1859 to a depth of 69½ ft, drilling has gone deeper and deeper until the industry is now drilling wells to more than 20,000 ft, or four miles down. Of course, deeper well drilling means increased costs to the producer. For example, wells drilled to 2000 ft cost less than $25,000; wells drilled deeper than 7500 ft cost over $100,000; and wells drilled deeper than 15,000 ft cost at least $500,000 and many cost more than a million.

Cost of equipping these wells, most of which are completed in hazardous high-pressure zones, are prohibitive. Similarly, cost of geological and geophysical research for new reservoirs and cost of acquiring leases increased appreciably in the last 10 years.

Hazards and Costs

It has been argued that prices should be based on the cost of present reserves, and when new reserves are discovered, a readjustment of prices based on new discoveries should be made. This will not create a desire on the part of risk capital to wildcat and discover new reserves due to the hazards encountered and the uncertainty of this type of industry.

An independent producer may take a certain amount of his current capital and set it aside to replenish his stock of goods (gas). When he finds himself depleting his capital structure, however, due to costlier acquisition cost of leases, higher drilling costs due to deeper drilling, and hazardous conditions of higher pressures, et cetera, he will retrench and slow down, because he does not know what his price will be under a regulated economy even if he does make a discovery.

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Helping others to help themselves... Assisting the injured and handicapped to return to personal independence... Helping reduce the costs of workmen's compensation insurance... These are some of the gratifying results of one of the important services provided by the Texas Employers' Insurance Association — A rehabilitation program for workers handicapped as the result of industrial accidents.

Under the direction of our Medical Coordinator, several registered nurses, specially trained in rehabilitation work, are employed to coordinate the efforts of doctors, hospitals, therapists, the injured worker, his family and employer... in rehabilitating the injured worker and returning him to employment in the shortest time, with the least disability. Last year thirty-two such cases were handled with excellent results.

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For full information, call or write our nearest service office listed below, or write direct to:

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I cannot imagine a worse situation than having a pipeline or distributing system without any gas to run through it, or an industrial plant without needed fuel.

Let's look at the oil industry, a similar industry to the gas industry. Unregulated, it has found and produced in time of peace and war a sufficient quantity of crude petroleum to meet the nation's needs at a price far below other commodities. Price of crude oil is universal, with slight variations, because of quality or transportation costs. It is neither based on the cheapest cost nor the highest cost but on the average, with incentive to discover new reserves to take care of an expanding and growing country. Let me illustrate a case.

Take the Rowan gas pool, a few miles out of Houston on land settled by my father in 1877, having moved there from Brooklyn, New York. The Houston Pipe Line Company was the only pipeline in the area when this field was discovered, and we were forced to sign a contract with them on their own terms and conditions. I hope the Democratic angels in Heaven intercede in behalf of my old friend, George Hill, and get a pardon from Saint Peter for all the sins committed by this otherwise great man against the gas producers of this state. I hope he is enjoying the celestial peace and happiness we all seek.

I told his successor in office that this contract was negotiated at the same "arm's length bargaining" as the Japanese Peace Treaty. It is my recollection that MacArthur wrote it and pointed a finger at the Japanese representative and said, "Sign it," which is what happened at Rowan gas pool. We delivered Houston a minimum amount of gas and drilled no new wells. Last year I renegotiated this contract. Two new wells were drilled and a third is drilling, and substantial quantities of gas are available for Houston's needs.

We sell this gas to Houston, an intrastate company, at a cheaper price than we were offered by an interstate pipeline for fear of the very things that are now happening—a freeze in prices.

Gas Prices

I do not believe that the Congress ever intended for the Federal Power Commission to regulate the price paid to the producer, and I think the Federal Power Commission correctly interpreted the Natural Gas Act of 1938. To my knowledge, we are witnessing for the first time in our nation's history an instance where an extractive industry has been declared to be a public utility.

Heretofore, public utility regulation has been imposed only where there was a monopoly on the supply of the commodity. Price behavior of natural gas has none of the symptoms of monopolistic control. Independent producers are vigorously competing with each other to find a commodity (natural gas) and then to sell that commodity in a competitive market. Prices of natural gas vary from field to field, and even within the same field.

Natural gas prices are not only competing with competitive fuels, but are actually in many instances priced far below such competitive fuels. And this is true notwithstanding the fact that the majority of consumers prefer natural gas to other fuels because of its cleanliness and convenience, and consequently would prefer to pay a higher price for it than to use other fuels.

In this connection, let me draw a contrast between the small independent gas producer and a large gas company or oil company producing gas. The small producer is usually faced with the necessity of financing his operations after a discovery. In order to borrow money, he must have a sale for his production (even his oil wells can be shut down if he flares his casinghead gas produced incidentally with his oil). A pipeline company knows this, and therefore is in a position to force him to sign a contract on their own terms and conditions and price, whereas the large company can withhold its production from the market and even pay shut-in royalty until the pipeline company meets its terms and conditions and price.

Utility-Type Regulation

The Federal Power Commission, mainly because of the Phillips case and the City of Detroit case, considers that under the law it must use the utility type regulation in dealing with independent producers. In the relatively few independent producer cases so far considered, it has become apparent that this method is unworkable. You can't determine the fair price for gas by relying mainly on a calculating machine.

Production of gas is inherently combined with the production of oil. You can't regulate the price of gas on a cost of service basis without making some kind of an arbitrary allocation of the joint costs. No satisfactory method has been found. Results are bound to depend upon arbitrary allocation.

This method in many instances sets a price of gas in excess of what you can sell it for. In other fields the price thus determined is far below the price you have contracted to sell it for, and below the reasonable market price.

This method wholly ignores the sanctity of a contract. The independent producer can't do his financing and develop his property under a type of regulation which destroys the sanctity of contracts.

Small Producer Typical

Too frequently people think that large companies are typical producers. Nothing could be further from the facts. It is the small producer who drills the vast majority of the wildcat wells each year. Large companies often farm out wildcat acreage to the small producer and come back for development if the wildcatting is successful.

The gas industry absolutely must have the efforts and the energy of this group of producers. Without their venture capital and venture personnel, a vital source for development of new reserves for both oil and gas will be lost. These people cannot compete with the large integrated companies in developing known gas reserves such as are found in the offshore areas of Louisiana and Texas. Costs are simply too prohibitive. They must confine their search to the undeveloped areas within the Continental United States. The activities of this group will cease if they are not permitted to earn enough income from occasional discoveries to reinvest in new adventures.

Harris-O'Hara Bill

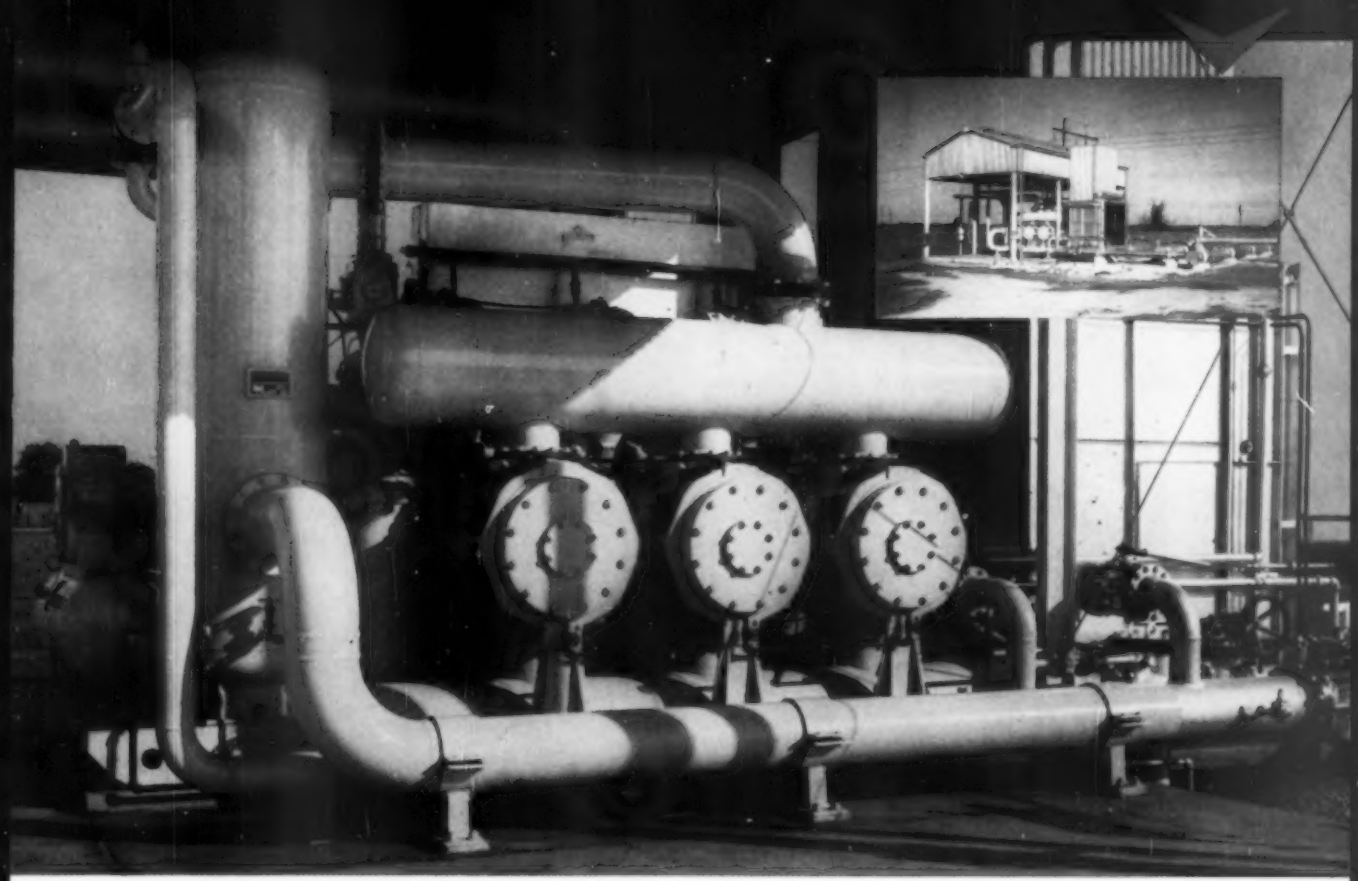
The U. S. Supreme Court is responsible for making this utility type of regulation necessary. Its decision is rank judicial legislation. Two Congresses have passed laws reiterating the fact that it was never the intention of Congress that we should have the situation existing today. There has now been introduced in the House a third law—H.R. 6790—sometimes referred to as the Harris-O'Hara bill.

This bill does not free the producer from regulation, but it does free him from the type of regulation the Supreme Court decreed. It does not go as far as I think it ought to go, because I believe the true public interest would best be served by letting competition between producers and between gas and other fuels control the price of this commodity.

It does have certain sedatives in it, however, that alleviate the pain of the independent producer to some extent. It will tend to create a better atmosphere. It will quell some of the confusion and frustration. It will empower the independent producer to continue to make his contribution toward supplying demands of present and future consumers. It holds out to him the hope of realizing such profit as will result to him from being able to sell his gas at contract prices he can rely on, and at the reasonable market value of the gas as a commodity. ★ ★ ★

TIPRO GAS PANEL

BEAIRD-INGERSOLL-RAND Packaged Compressor Plant



UNITED GAS PIPELINE COMPANY'S Monroe Field Station No. 1 equipped with a Beaird-Ingersoll-Rand 6SVG 330 h. p. packaged compressor complete with all necessary controls for unattended operation. Other sizes from 120 to 660 h. p.

Unattended Operation-

HIGH VOLUME BOOSTER STATION

BEAIRD
another AMF product
PACKAGED COMPRESSOR PLANTS

LOWEST COST PER HORSEPOWER INSTALLED

UNITED GAS PIPELINE COMPANY has installed this Compressor Station near Sterlington, Louisiana. Equipped with a Beaird-Ingersoll-Rand 6SVG 330 h.p. packaged compressor, the station is an integral part of United's Monroe Field facilities. Gas from declining wells in the field are boosted from 10 psig to main line pressure of 25 psig. Ten million cubic feet per day are handled by this single Beaird unit.

Designed for unattended operation, the compressor is equipped with regulators that enable the driving engine to throttle from half to full speed to maintain constant discharge pressure. Should operating conditions become less stable, compressor valve unloaders can be installed which will provide completely automatic operating control. The compressor will then unload its cylinders in steps, maintaining precision discharge pressure to the main line. When the condition causing the pressure build-up is eliminated, the unit would automatically close the unloading valves and pick up the required load.

Let us show you how a Beaird-Ingersoll-Rand packaged compressor plant can be designed to meet your special requirements.

THE J. B. BEAIRD COMPANY, INC.
Shreveport, Louisiana
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- High strength joint
- 100% leak resistant

J&L Extreme Line casing meets the challenge of your toughest deep well problems. Investigate the unusual advantages of this new J&L casing available in grades J-55, N-80 and P-110. Write for complete details to the Jones & Laughlin Steel Corporation, Dept. 418, 3 Gateway Center, Pittsburgh 30, Pennsylvania.

High joint strength. A modified Acme-type (rectangular thread form) thread with a steep flank angle assures a strong interlock, takes tensional loads in shear.

100% leak resistant. Separate sealing surfaces lock together when two lengths of casing are joined. Seal consists of a curved surface extending beyond the male threads and a tapered conical seat beyond the inside end of the mating female threads. The number of threaded connections is halved.

J&L STEEL **Jones & Laughlin**
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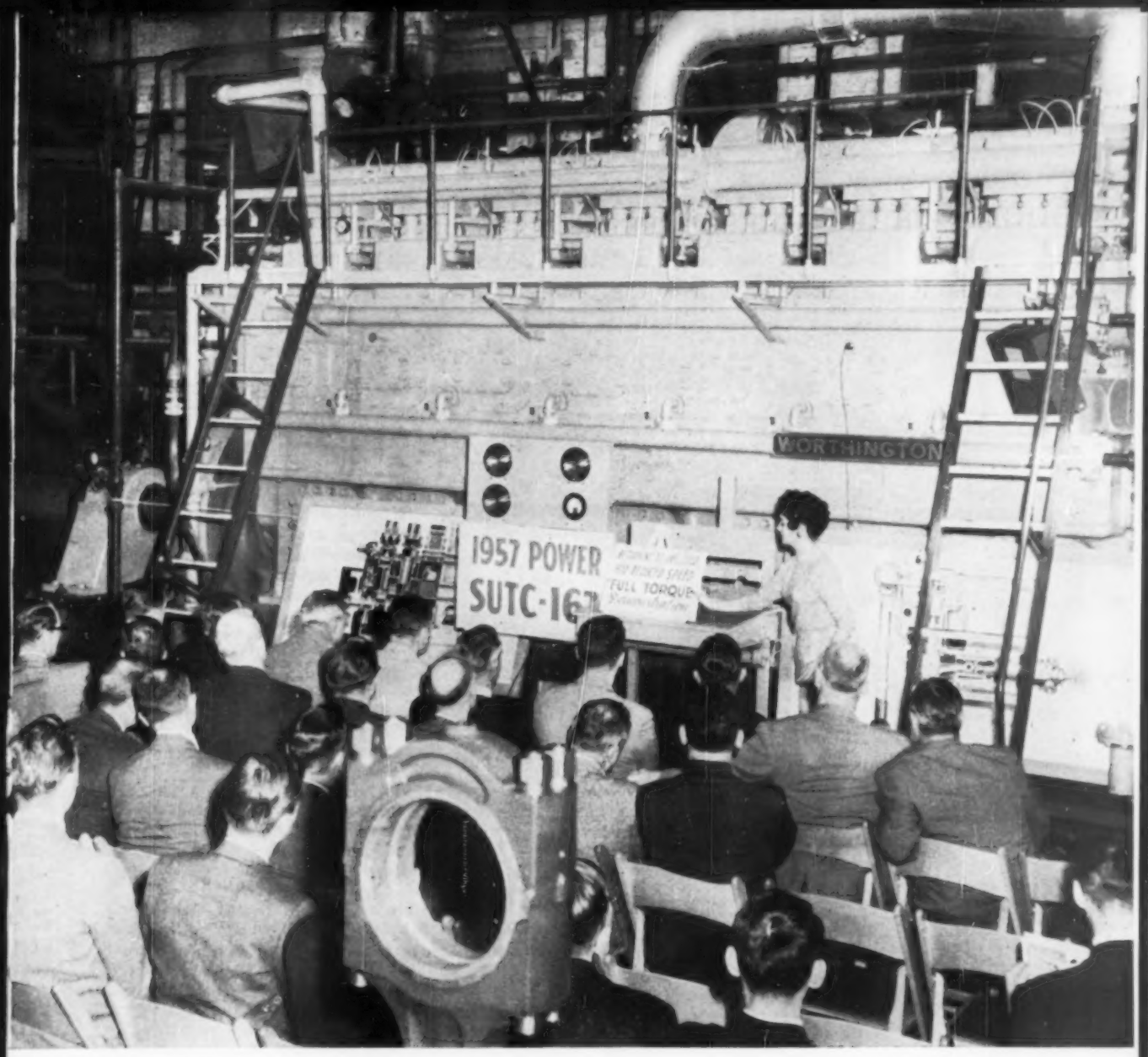


At 1957 Power Fair, engineers witness proof of...

TURBO-UNIFLO PERFORMANCE

There's no better way to judge the performance of an engine than to see it in operation. That's why more than 250 process and pipeline engineers recently gathered in Buffalo, N. Y., to attend Worthington's 1957 "Power Fair."

Star of the show was the new SUTC TURBO-UNIFLO gas engine compressor. The only two-cycle engine compressor with exhaust powered turbocharging from start-up through full-load, the TURBO-UNIFLO features remarkable stability over the complete range of speed and load requirements.

The audience was impressed by the TURBO-UNIFLO's smooth start and quiet operation (as much as 20 decibels quieter than engines with mechanically driven scavenging systems). Next came the overload demonstration to prove the very conservative engine rating.

To show stability, engine speed was gradually reduced while maintaining full torque. 320 rpm . . . 270 rpm . . . 230 rpm (at this point someone offered to bet that it couldn't go below 150). But down it went . . . all the way to 105 rpm before reaching its stalling point.

But this is only half the story. Your Worthington representative will be glad to give you all the facts about the new SUTC TURBO-UNIFLO engine. Get in touch with your nearest Worthington district office or write to Section E-73, Worthington Corporation, Harrison, N. J. In Canada: Worthington (Canada) 1955, Ltd., Brantford, Ont. E-73

WORTHINGTON

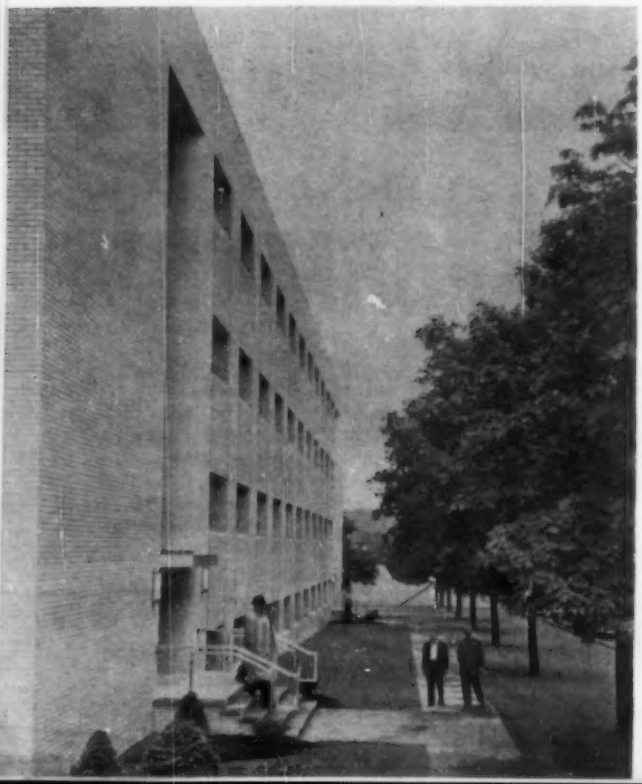
Gulf Research Center. Aerial photo of 44 buildings at Harmarville, Pennsylvania, where three new laboratories were formally opened May 29. First building went up in 1935. This is the largest concentration of research laboratories in the petroleum industry.

General Matthew B. Ridgway, chairman, Board of Trustees, Mellon Institute, made keynote speech.

William K. Whiteford, president, Gulf Oil Corporation, gave dedication speech.

Dr. Blaine B. Wescott, Gulf vice president-research, heads growing Research Center.

Production lab building. The William Larimer Mellon Research Laboratory where facilities are provided for research in every phase of drilling, production and transportation. This view shows how the well landscaped grounds resemble a university campus.



Ernestine Adams

THE guide pointed to a man working at a table with a microscope in a corner of the machine shop.

"Here is our watch repair man," he said. "Our technical people use 300 stop watches that have to be kept in repair."

The watch repair man is one of 1300 persons, most of them scientists and specialists, who work at the large Gulf Oil Corporation Research Center, Harmarville, Pennsylvania. After spending a day covering the place, you don't wonder that 300 stop watches are needed.

Three new laboratories were recently added to the 41 buildings already on the 53-acre grounds. The cluster of laboratories and service buildings set on a carpet of green and bordered by trees and shrubs has the appearance of a university campus.

New laboratories are the Richard Beatty Mellon Automotive Products laboratory, designed for research into fuels and lubricants; William Larimer Mellon Production Research laboratory and Drilling building, where new drilling and production methods are being investigated; and Andrew William Mellon Nuclear Science laboratory, in which uses of nuclear energy in the petroleum industry will be studied. The buildings are named after three men who were successful executives and organizers of the company.

For five days Gulf Oil held dedication ceremonies and entertained inspection groups from the press, scientific circles, the industry, company employees, and the public.

Dr. Blaine B. Wescott, Gulf vice president of research, presided at the dedication ceremonies.

"One of the major characteristics of the petroleum industry is that we probe the past, scrutinize the present, and peer into the future," said President William K. Whiteford in his dedication address.

General Matthew B. Ridgway, chairman of the board of Mellon Institute, pointed out in his keynote speech that researchers in the natural sciences and in the human and social sciences, including economics, finance, and politics, are all interdependent.

"We have an imperative need for an integration of effort in all lines of research," he said.

Dr. Wescott stated in a press interview that operating expenses of the Research Center ran over $1 million a month. He said that the Gulf Center was the most highly concentrated oil research center in the country. All branches of petroleum

Miss Adams is Management Editor.

Here Scientists Seek Every Clue to Oil Behavior From Exploring to Marketing

Three New Laboratories Make Gulf's Research Center One of World's Largest

operations are under study. Research projects are, of course, closely tailored to fit the Gulf organization needs. Some 40 main projects are under study, but there are many subdivisions, so that the total studies run to about 350.

An estimated 15 percent of all research at the Center is devoted to basic investigation designed to provide fundamental facts.

Exhibits to demonstrate the various projects included:

Geology. Study of processes that govern the gradual formation of layered rocks and salt dome structures.

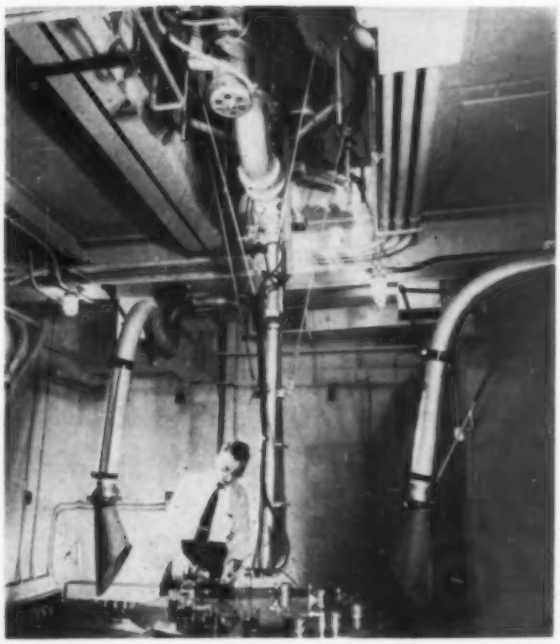
Reservoir Mechanics. Three types of production mechanisms were demonstrated: Solution gas drive, gas cap expansion (accompanied by gas injection) and waterflooding. Another exhibit showed in-situ combustion method of recovery. Field tests produced 85 percent oil recovery.

Production Engineering. The Batch Interface Detector developed by Gulf Research was displayed. This permits transportation of various products in one pipeline. Modifications of the interface detector are being used in oil fields, on tankers, and in reservoir studies.

Geophysical Research. The "Profile Printer" exhibited is a seismic device developed by Gulf. It is said to reveal the most complete picture of underground formations yet obtainable through surface exploration.

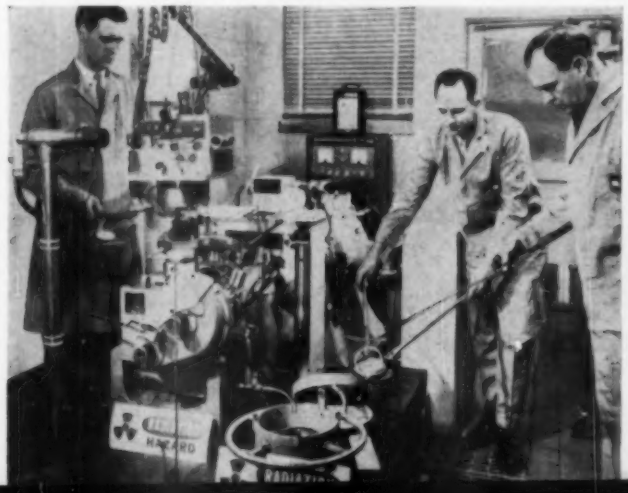
Nuclear Science. On display was the giant three million volt Van de Graff particle accelerator, which Gulf scientists plan to use for fundamental research in nuclear physics and to study radiation effects on petroleum and chemical processes.

Automotive Engineering. Some of the 40 high-compression, multi-cylinder test engines were displayed. ★ ★ ★



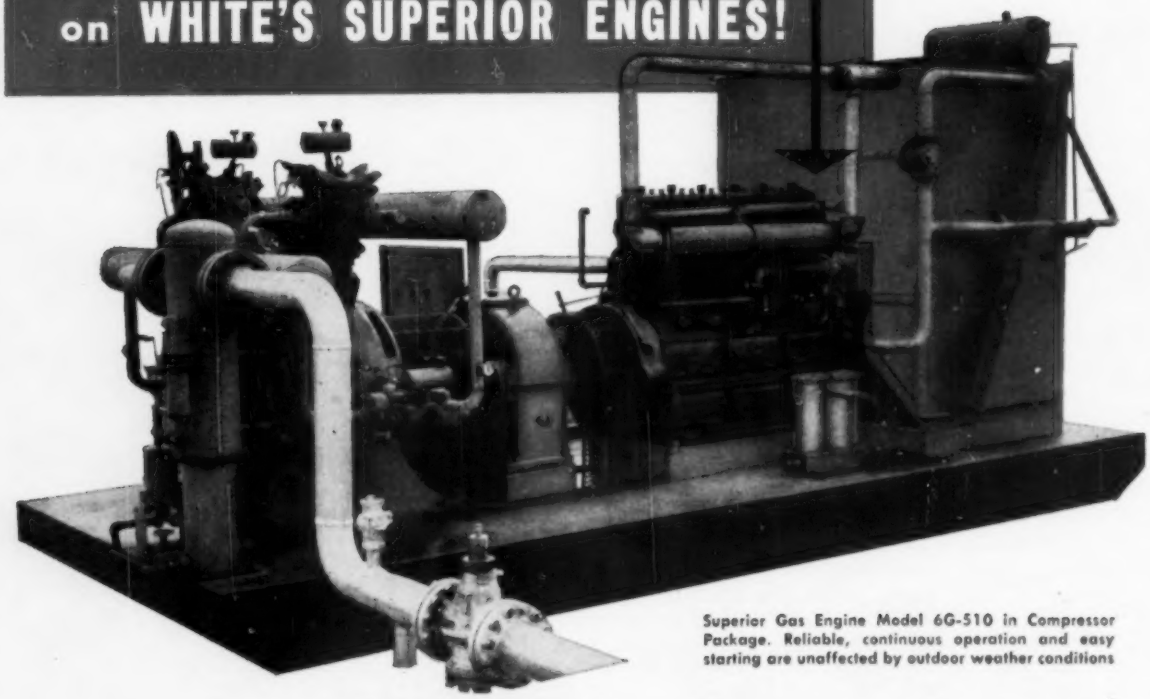
Three-million volt jolt is delivered by the business end of Gulf Oil's new "atom smasher," central equipment of Nuclear Science laboratory. Most versatile radiation source in private industry, the machine will be used in probing new frontiers for application of nuclear energy to petroleum operations, and creation of new products.

"Hot" piston ring. Specially trained mechanics remove radioactive piston ring from engine in one of several research projects with radioactive "tracers" at Automotive Products laboratory.



Brother, it's cold down there. It's 70° below zero to be exact! Window of instrument panel looking into cold room in Automotive Lab shows technicians checking how products stand up in deep cold.

Here's Proof...you can depend on WHITE'S SUPERIOR ENGINES!



Superior Gas Engine Model 6G-510 in Compressor Package. Reliable, continuous operation and easy starting are unaffected by outdoor weather conditions

more than *50,000 Hours Continuous Operation!* no major overhaul or part replacement!

Service records show Superior's first major repair usually comes due long after other engines would be completely replaced . . . over 50,000 hours continuous operation has been reported with no major overhaul or major part replacement required. White's extreme design simplicity makes this possible. High mortality parts are eliminated, thus prolonging engine life and reducing repairs and maintenance. Relatively few cylinders and internal parts supply power equal to other engines having more cylinders and more complex design. Precision construction and advanced engineering refinements reduce wear on all parts and guarantee low lube oil consumption. Highly developed, rugged, open chamber combustion system assures maximum fuel economy and also exclusive operation on non-premium fuels. Cost-per-horsepower operation is much lower than comparable models in the same power range. Conservative horsepower ratings allow plenty of reserve to meet extreme operating conditions.

It all adds up... Superior is the engine you can count on!

Diesel, dual-fuel or gas engines range from 190 to 2150 H.P. Portable or stationary generator sets range from 150 to 1500 KW. For pipe line pumping, gas compressor drive and power generation, specify modern, compact, powerful Superior engines . . . field-proven in hundreds of oil field applications! Write today for additional information!

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Used by more drillers on more mud pumps than any other V-belt made

World leadership is the result of these 4 engineering developments

1. Tougher, more resilient cords are able to absorb the severe pulsations of mud pumps; easily handle peak loads.

2. True-fitting concave sidewalls (U. S. Pat. No. 1813698). As a Gates Belt bends around a sheave, the concave sides fill out . . . become straight . . . fit sheave grooves evenly. (Fig A.) This uniform groove contact insures greater pulling power, less wear, longer life.

Straight sided belts bulge at the sides when bent. Uneven contact (Fig. B) causes uneven wear; shortens belt life.

3. Stabilizing ribbed tops (U. S. Pat. No. 2548135) are exclusive with Gates. They dampen vibration, protect top of belt from damage, keep belt running smoothly over idler-equipped mud pump drives with no side whip.

4. Flex-Weave cover (U. S. Pat. No. 2519590) provides greater flexibility with far less stress on fabric. Wears longer . . . lengthens belt life . . . lowers belt costs.

The four engineering developments shown at left make Rib-Top an outstanding performer in mud pumping operations.

Yet Rib-Tops cost no more than ordinary belts of comparable ratings.

For fewer V-belt replacements and lower costs on mud pump drives, always specify Rib-Top. Both Standard and Super Rib-Top are available at your nearby oil field supply house.

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World's Largest Maker of V-Belts

Put Super Rib-Top on the tougher drive jobs. With 40% greater horsepower capacity, Super Rib-Top easily handles drive overloads. Fewer belts and narrower sheaves solve space and weight problems.

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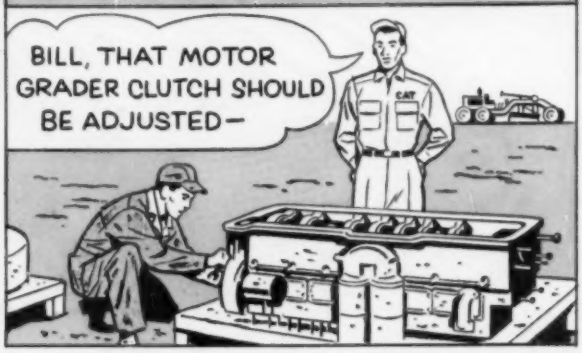
DEVELOPED ESPECIALLY FOR MUD PUMP DRIVES

TPA 167

THE CASE OF
THE SLIPPING MAINTENANCE PROGRAM



I KNOW, BUT I'M MUCH TOO BUSY! OURS IS A BIG OPERATION, YOU KNOW.
CAN WE HELP? WE COULD HANDLE YOUR MAJOR RECONDITIONING JOBS, THEN YOU'LL HAVE MORE TIME FOR MAINTENANCE. WHY NOT TALK TO THE BOSS?
CAT

—AND WE HAVE SPECIALIZED REPAIR BAYS WHERE WE CAN REALLY DO A COMPLETE JOB! DO IT QUICK, TOO.
LET'S GIVE IT A TRY. WE'LL SEND OUR BIG REPAIRS IN TO YOU CHAPS!
CAT

SOME DAYS LATER
THERE! THIS ONE'S READY TO ROLL AGAIN. WE'RE CERTAINLY KEEPING AHEAD OF MAINTENANCE AROUND HERE THESE DAYS!
LET'S CHECK ON MACHINE NO. 17. THE OPERATOR REPORTED A LEAKY PUMP—

AND, MY MAINTENANCE PROGRAM IS DEFINITELY WORKING SINCE YOU TOOK OVER THE TIME-CONSUMING REPAIR WORK... WE ALSO HAVE FEWER MAJOR REPAIRS NOW.
GOOD! SAY, HOW ABOUT ATTENDING ONE OF OUR FUTURE CAT CARE SCHOOLS?
PILLAR

CATERPILLAR*
*Caterpillar and Cat are Registered Trademarks of Caterpillar Tractor Co.
CAT CARE FOR LONGER WEAR
LET ME HELP KEEP YOUR CAT* EQUIPMENT ON THE JOB!
Caterpillar Tractor Co., Peoria, Illinois, U.S.A.

LIFTS 15 TONS

TRAVELS 21.5 MPH

Take another look at this Koehring 205 Cruiser. It brings you the economy of one-man control for crane work-and-travel — *plus road speeds up to 21.5 m.p.h.* This way, one fast-moving Cruiser efficiently serves several widely-separated work-areas — travels 30, 40 miles or more to do a special lifting or material-handling job — and returns, all in the same day.

30% gradability

Cruiser highway travel is unrestricted. Overall width is only 8 feet. Axle-load distribution meets street and highway regulations in most areas — even when carrying 25-foot folded boom. For all its speed and roadability, the 4-wheel-drive Cruiser has plenty of tractive power. It climbs 30% grades — is easy-handling, maneuverable on or off-pavement. Turns in 27½-foot radius — has power-steering, smooth torque-converter drive, big air-hydraulic brakes. One engine supplies all power for work and travel — one man controls all operations. Consider what this, alone, can mean in lower costs, and increased efficiency on your work.

Big work capacity

In addition to 21.5 m.p.h. travel speed, you also get a full range of low shuttle speeds from 0 to 7 m.p.h. for lift-and-carry. It safely lifts up to 15 tons (based on 85% rating). Boom lengths range from 25 to 70 feet. Or, 15 to 30-foot jib can be added to 65-foot boom. As a clamshell or dragline, the Koehring 205 Cruiser handles ½ to ¾-yard buckets on a wide work radius. It readily converts to ½-yard shovel or hoe. Truck or crawler mounting also available. Call Koehring distributor — or write us today for complete details.

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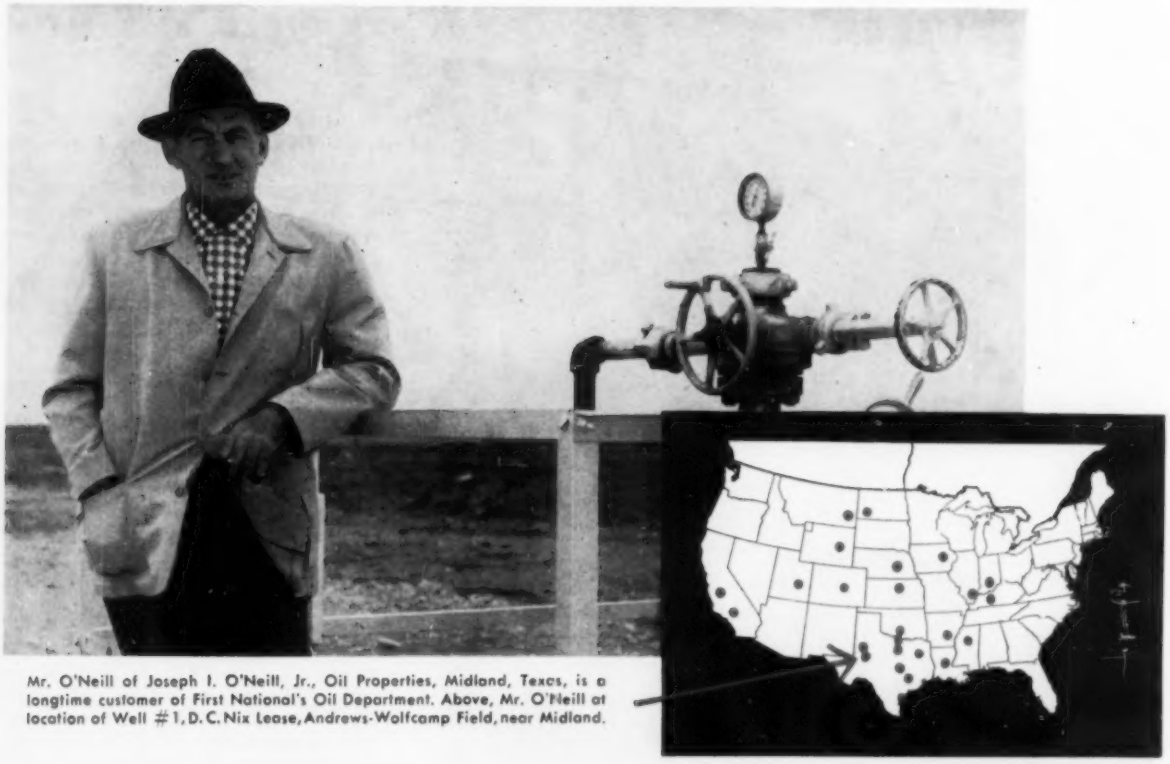
goes where you go...



Mr. O'Neill of Joseph I. O'Neill, Jr., Oil Properties, Midland, Texas, is a longtime customer of First National's Oil Department. Above, Mr. O'Neill at location of Well #1, D. C. Nix Lease, Andrews-Wolfcamp Field, near Midland.

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Tees are quickly welded to line and small line completed to first valve. A Mueller Drilling Machine is then used to drill through the tee and activate the line. Drilling is done through a valve mounted on top of the tee for complete control of pressure at all times.

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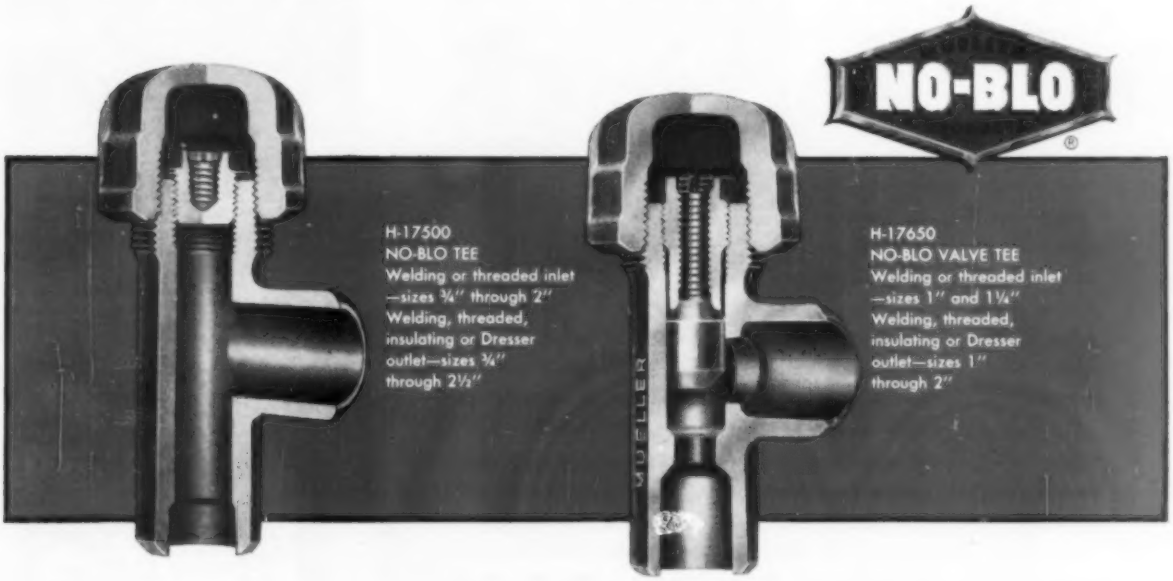
Pressures to 1200 p.s.i. at 100° F.	"EH-1"
Pressures to 1200 p.s.i. at 100° F.	"DH-2"



Contact your Mueller Representative or write direct for complete information on these and other NO-BLO fittings and equipment.

MUELLER CO.
DECATUR, ILL.

Factories at: Decatur, Chattanooga, Los Angeles;
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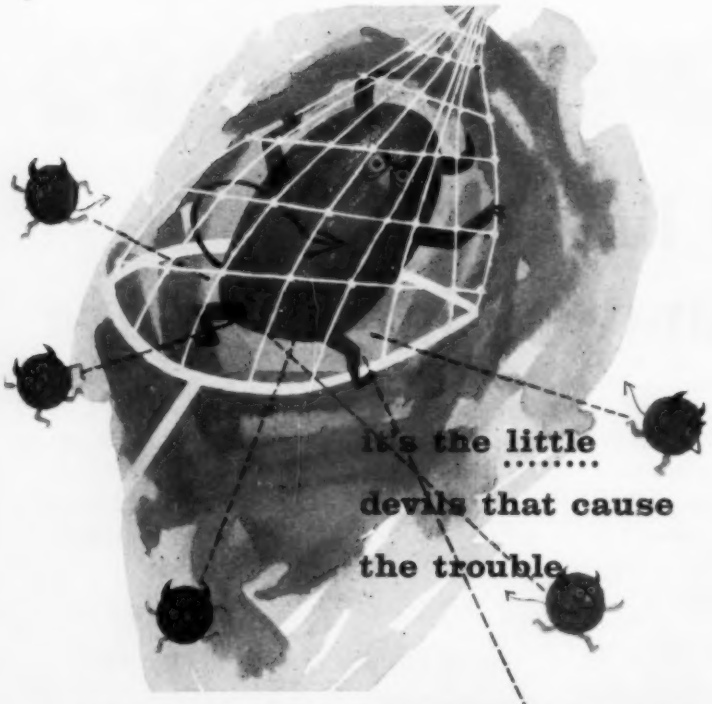
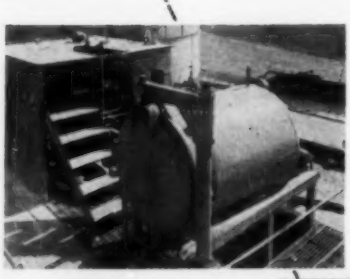


In water flooding, almost any treatment will remove the larger solids. However, the microscopic hellions — algae and bacteria, particularly the sulphate-reducing bacteria — are what really play hob with the flood zone. And conventional treatment lets most of them through. But Dicalite filtration nets them securely, because Dicalite filteraids can filter out particles smaller than the wave length of visible light, particles so small you can't see 'em with a microscope!



but Dicalite will trap them!

Dicalite filtration in completely unitized filter systems does the same job in salt water disposal . . . and for exactly the same reasons. Witness this compact unit operating in Huntington Beach, California, on the disposal of oil field brines.

These brines contain both oil and colloidal clay, 110 to 170 ppm, which must be removed before disposal in open streams to avoid water pollution in this populated beach resort. This completely unitized Atlas "Filtreat" unit, using Dicalite 'Speedplus' with a precoat filteraid, removes all contaminants, including algae and 97-99% of all bacteria, from 4,700 bbls./day. This unit features automatic operation, including controls for precoating and body feed, in a space only 10'x24', including the platform. The operator visits the installation only once or twice a day. Cost of operation — about 1/10¢ per barrel! Write for information.

Dependable GLC GREAT LAKES Dicalite® DIATOMACEOUS MATERIALS

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Personals

John H. Thacher will succeed **S. Z. Natcher** in London as president of Iran California Oil Company, subsidiary which manages Standard Oil Company of California's interests in Iran.

E. S. Neal, a director of Imperial Oil Limited for four years, has resigned to accept the position of deputy representative on Middle East matters for Standard Oil Company (New Jersey). His offices will be in London, England.

Jesse D. Winzenried was named assistant to the president of Husky Oil Company. Winzenried has been administrative coordinator for Husky since April 1956. In his new capacity he will fill the position left vacant last October when **Maurice E. Smith** was named vice president, finance.

John Wagner Jr. was elected vice president of A. V. Smith Engineering Company. In this capacity, Wagner will direct field corrosion studies and research work.

Convention planners for the Sixth Annual Convention of the Association of Desk and Derrick Clubs of North America are, left to right, Edna Hurry, ADDC past president, New York; Peg Grant, co-chairman ADDC Convention, Chicago, Emily Fairbanks, convention chairman, and Irma Cline, ADDC president, Wichita Falls. The convention will be held August 30-31 in Chicago, whose club will be official hostess to the 117 clubs in the United States and Canada.

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"ARMSTRONG BROS" Pipe Vises. Standard Hinged Vises have drop forged (unbreakable) hooks, and replaceable tool steel jaws. Smaller vises have 1-piece jaw which prevents kinking of small or thin wall pipe. T-Handles have oval ends that will not pinch hands. The Open Side Vise mounts on a bench, truck, or with special chain attachment on any post or tree. The Chain Vise has drop forged base, jaws and handle. Chains are proof-tested. Patented 1-piece jaw prevents damage to small pipe, thin wall conduit or tubing.

Write for Pipe Tool Circular

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PREVENT DISEASE & INFECTION!

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12 Oz. Bombs

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SEE YOUR LOCAL SUPPLY DEALER!

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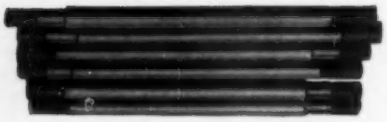
Pump rods hard-faced by ThermoSpray Process give 20 times longer service



New Metco Process hard-faced acid sludge pump rods serve as much as 20 times longer than unfaced rods.

A number of oil companies are making important savings in equipment down-time and replacement part costs with the METCO THERMOSPRAY* Hard-Facing Process. Typical of these parts are pump sleeves, as well as the acid sludge pump piston and rods shown here. Operating conditions were severe—rods had to be replaced every 24 hours—new packing every 8 hours. Hard-faced rods now last over 500 hours; packing more than 60 hours. Coatings are extremely dense and non-porous—homogeneous.

The THERMOSPRAY Hard-Facing Process consists of spraying specially developed alloys in powder form with the METCO THERMOSPRAY GUN. No compressed air is required. Coatings have hardness of Rc 30 to Rc 65, depending on the specific THERMOSPRAY alloy used; will outwear hardened steels from 3 to 10 times. Spraying speeds are higher—8 to 10 lbs. per hour—and deposit efficiency far greater (up to 97%)—than with any other type of available equipment. Hard surface depth can be closely controlled and the smooth surface left after spraying requires a minimum of finishing.

Write today for free descriptive Bulletin 126A or a call by a full-time, company-trained, Metco Field Engineer in your territory. Or see your local metallizing job shop.

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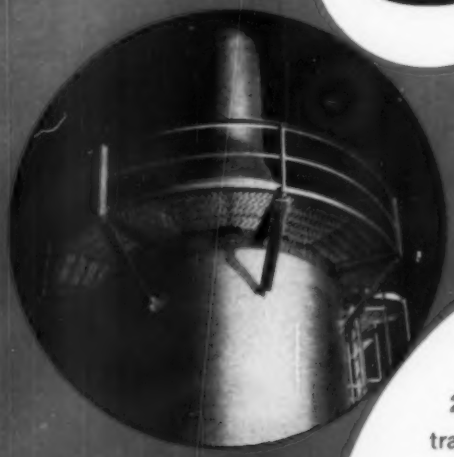
you can judge

the comparative values of furnace design as applied to operating requirements.

It's quite simple

there are 9 basic factors

which must be evaluated to obtain the full comparison of values



1—Average radiant transfer rate. 2—Maximum deviation from average radiant transfer rate. 3—Average and maximum transfer rate in convection section. 4—Maximum tube wall temperature, radiant or convection. 5—Maximum efficiency with specified excess air. 6—Controlled thermal recirculation of flue gases to provide even heat distribution throughout full length of each tube and equalized heat distribution around each tube. 7—Overload and corresponding transfer load. 8—Design to provide: structural column supports - Ladders - Platforms - Tube Removal facilities, etc. 9—Degree of assembly; of the furnace structure and of the heating surface.

Whenever all these 9 specifications are applied to all the operating requirements, you can be sure PETROCHEM ISOFLOW FURNACES will be found most economically desirable.

No other furnace design can claim the recognition and acceptance achieved by PETROCHEM ISOFLOW FURNACES . . . starting with one installation in 1940, January '57 records more than 1650 ISOFLOW FURNACES in operation and under construction—a record that is incomparable just as all Petrochem Isoflow furnaces are more economically desirable by any comparison.

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NOT EVEN FIVE FEET OF PEAT BOG CAN HANG UP THE NO. 583

The Cat* No. 583 Pipelayer is not only the highest capacity pipelayer in history—but the most efficient. Mannix Ltd., Calgary, Alberta, has four of them in its 100% Caterpillar spread laying 110 miles of 30-inch gas line through southern British Columbia.

The line takes the No. 583s through 40 miles of reclaimed lake bottom, covered with heavy silt and peat bog four to six feet deep. But the No. 583 has a full 21-inch ground clearance, and the bog can't stop it.

These big yellow units were engineered to give you a full day's work no matter what the terrain. For this machine was designed after consulting spread superintendents, foremen, mechanics and operators throughout the industry. It incorporates all their ideas of the ideal pipelayer. As a result you have the first machine that is *all pipelayer.*

It has 130,000-lb. lifting capacity and its engine delivers 191 HP. There is a three-stage torque converter in the main drive and new hydraulically actuated counterweights. And the extra high bottom clearance of the counterweight pivot, coupled with the ability to retract the counterweights well over the tracks, means that the No. 583 can maneuver easily even while handling an extra heavy load on a narrow right of way.

Here's the safest, fastest, most efficient machine ever designed for pipelaying. Behind it stand an army of Caterpillar Dealers always ready to give you quick service with quality factory parts wherever the pipe takes you. Call your Caterpillar Dealer today. You name the date—and he will demonstrate on *your* job.

Caterpillar Tractor Co., Peoria, Illinois, U. S. A.

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(Ages 27-38)

The expanding technical organization of a major integrated U. S. oil company operating in Venezuela has outstanding career opportunities and excellent growth possibilities for qualified petroleum engineers. Position vacancies exist at levels requiring FIVE to TEN years of specialized or general petroleum engineering experience. MECHANICAL ENGINEERS who have had experience in the design and construction of crude oil producing facilities, oil gathering stations, water flood projects, etc. are preferred. Applicants are invited to send complete resume of work experience and personal data. Replies are of course confidential. Personal interviews will be arranged for qualified candidates. Salary, including bonus, $14,800-$18,000, depending on qualifications and experience. Company is a leader in the petroleum industry with an excellent schedule of employee benefits, including home vacations with travel expenses.

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NATIONAL "COG"* SEPARATORS DO THE JOB

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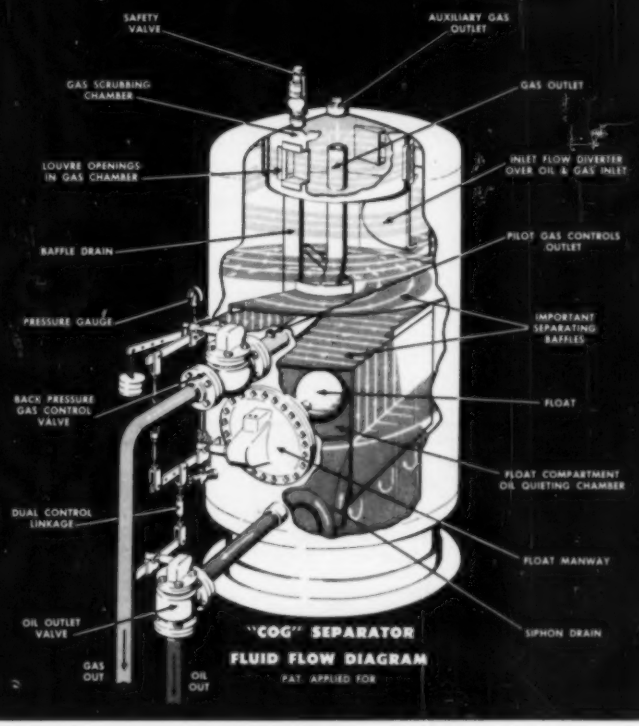
IT'S WHATS IN A SEPARATOR THAT COUNTS



"COG" SEPARATOR
FLUID FLOW DIAGRAM
PAT. APPLIED FOR

FOR MAXIMUM CONSERVATION OF OIL AND GAS

FLOW DESCRIPTION

The incoming well fluid enters the separator through a specially designed extra heavy cast steel diverter that turns the well fluid against the circular side walls of the separator, thus giving the incoming fluid centrifugal motion. An adequate side wall wear plate at the inlet prevents wall erosion.

OIL STREAM

The oil travels circumferentially about the separator in a relatively thin film, thereby presenting a larger surface from which the entrained gas is "broken out." This larger oil surface contributes toward greater oil capacities. The greater the fluid volume at the inlet, the greater the initial fluid velocity and the longer the scrubbing travel against the side wall of the separator; that is, the higher the jet velocity at the inlet, the farther the fluid will travel around the side wall of the separator before coming in contact with the first horizontal baffle plate.

Here the liquid continues to be spread in a thin film forcing more gas to be liberated, then the liquid cascades from the first horizontal baffle plate down to the top of the quieting chamber to continue its travel in a thin film. The liquid flows over the quieting chamber roof and side wall. Note that oil is collected outside of the quieting chamber and has further opportunity to liberate entrained gas. The oil in this chamber containing the least entrained gas is drawn off the bottom and flows under the baffle into the final quieting chamber. The oil is withdrawn from the bottom of the separator through a siphon oil outlet.

Free gas is prevented from entering the quieting chamber which assists greatly in producing early equilibrium at the separator pressure. The quieting chamber provides a relatively quiet surface within the separator on which the float rides thus conveying smooth action to the oil valve actuating equipment.

GAS STREAM

The gas stream, after initial or inlet separation, travels a well designed tortuous path, such that proper velocities are maintained through the gas scrubbing stages. The gas stream undergoes centrifugal scrubbing against the separator shell, against the outer surface of the gas chamber and through numerous louvre openings in the chamber wall as it enters the chamber. Inside the chamber it is further scrubbed on the inner walls. The oil that is entrained with the gas is drained away from the scrubbing gas stream through the drain pipe to the quieting chamber.

NEW IMPORTANCE of DE-GASSING OIL

THE "COG" WILL HANDLE MORE OIL TO THE SAME DEGREE OF DE-GASSING THAN SEPARATORS OF THE SAME RETENTION VOLUME; or, DO A BETTER JOB OF DE-GASSING AT THE SAME THROUGH-PUT of other types of separators of the same retention volume.

NATIONAL TANK COMPANY

TULSA, OKLAHOMA

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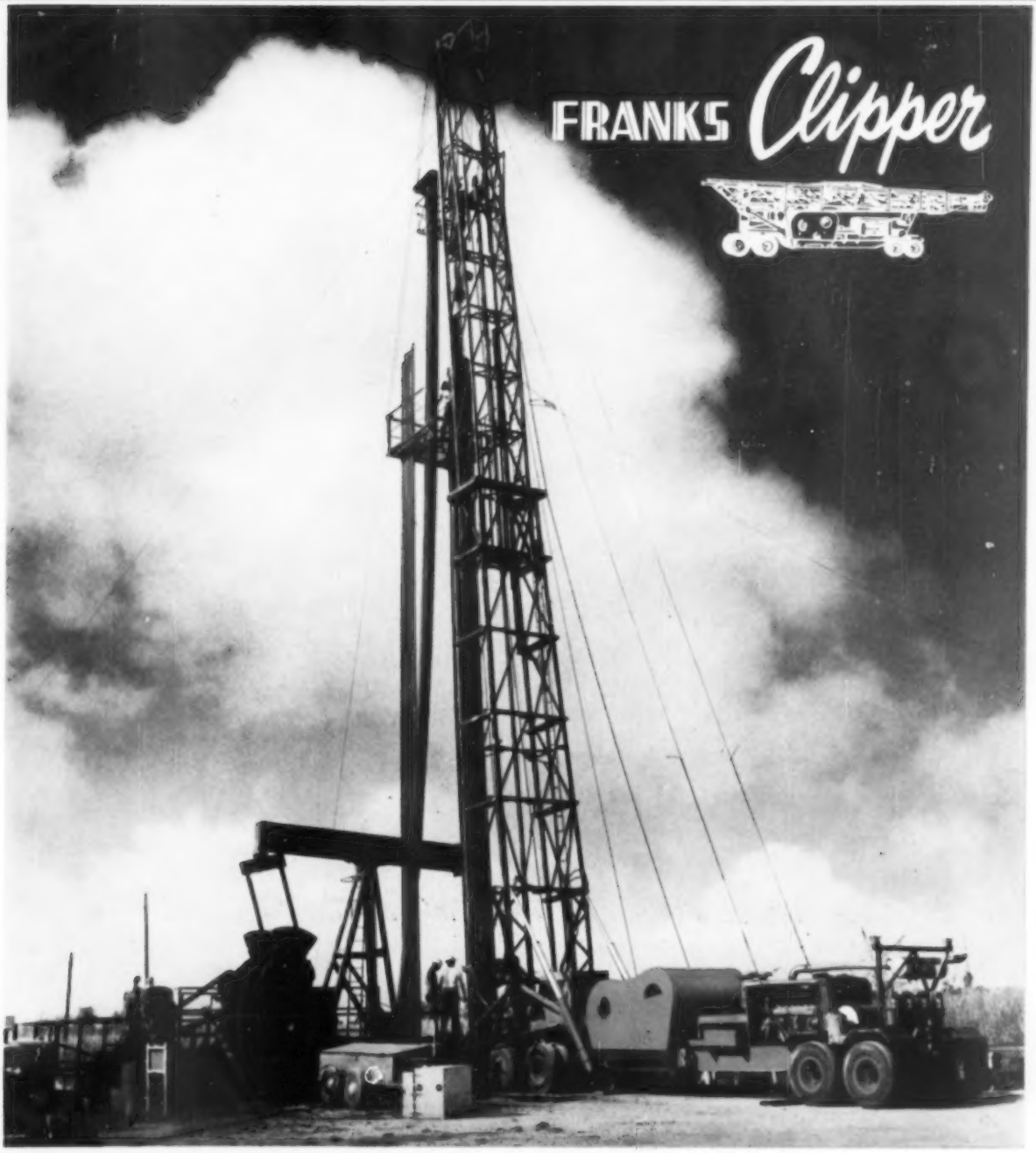

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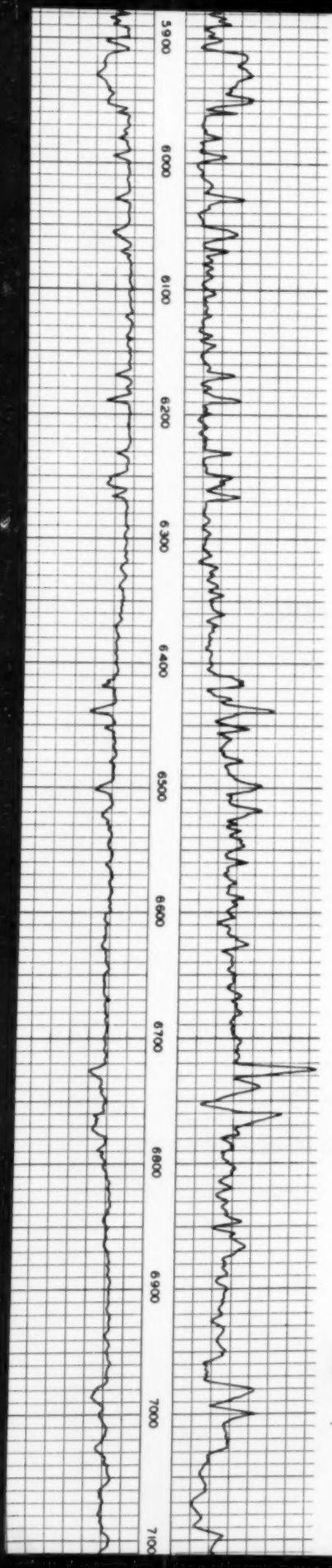
FRANKS Division, Cabot Shops, Inc., P. O. Box 3218, Tulsa, Oklahoma
"On the Spot" Field Service



Here's why

you get more information from

LANE-WELLS RADIOACTIVITY WELL LOGGING

You get more information from Lane-Wells Radioactivity Logging because more wells in every field, including your local area, have been radioactivity logged by Lane-Wells personnel than by any other service company This means Lane-Wells has more experience – more cumulative radioactivity logging knowledge of your local stratigraphy than anyone else. That's why you get more information – information you can rely on from Lane-Wells Radioactivity Well Logging. Call your Lane-Wells man today.

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LANE-WELLS CANADIAN CO IN CANADA

Of Things To Come . . . In Oil

OIL SHALE REFINING IS HERE, and future for commercial recovery is looking bright, assures A. C. Rubel, president of Union Oil of California. The company plans construction of a $200,000,000 shale extraction plant in the "next 10 years or so" to fully exploit Western Colorado shale reserves. Such a plant would produce 15 to 20,000 bbl of oil daily; present pilot plant turned out 4000 bbl in less than a month.

MILITARY "LAND-GRABBING" WILL BE CURBED — and soon. Oil industry, Department of Interior and most states and territories have lined up solidly behind a bill to prevent Department of Defense from establishing a huge Air Force training range over the outer continental shelf off the Gulf Coast. Legislation would limit to 5000 acres each the single pieces of public domain that the military could pre-empt without consent of Congress.

"LONG, SEARCHING LOOK AT DEPLETION in the not-too-distant future" is held certain by A. E. Herrmann, retired president of TIPRO. The Texas independent operator predicts a thorough study by Congress, which he says will prove the necessity of present allowance to domestic operators, but suggested that international companies' "subsidies and special tax exemptions" would not fare so well under congressional guns.

GREATLY EXPANDED DRILLING PROGRAM is a must if domestic oilmen are to find 3.6 billion bbl of oil per annum necessary to maintain adequate reserve inventory. To meet the demand, 735,000 wells will need to be drilled in the next decade in the U. S., warns Kenneth Hill, vice president of the Chase Manhattan Bank of New York. Domestic oilmen have not kept reserve to production ratio on par in the past five years.

LACT WILL MOVE 2,000,000 BBL OF CRUDE this year as automation in production begins to click. In the U. S. and Canada during 1956 LACT (lease automatic custody transfer) systems moved "at least 1,500,000 bbl of crude, valued at $4,000,000 . . . in a manner acceptable to both producer and transporter," states S. H. Pope, Gulf Oil Corporation, Tulsa, in a recent API paper.

NEW PERCUSSION DRILL LOOKS PROMISING in drilling through chert, dolomite and hard limestone. Gulf Oil, in drilling more than 6000 ft in West and East Texas, Nevada, Oklahoma, and Canada, achieved penetration rates up to 50 percent better than with conventional drilling. The drill was returned to Gulf's research laboratories in Pittsburgh, and an improved model looks even better.

TOPS IN SPUDDERS *plus*
unmatched quality in service

More and more experienced drillers throughout the country are buying Bucyrus-Erie spudders because they know they're getting a machine with a proved profit-making record on a variety of drilling and servicing jobs. Among the features that contribute to this outstanding spudder performance are: fine engineering, rugged structural design; durable, long-life construction; good mobility; sharp, snappy spudding action; and day-in, day-out dependability.

AND BUCYRUS-ERIE'S "AFTER-THE-SALE" BONUS — PROMPT, EFFICIENT SERVICE—KEEPS THESE MACHINES IN TOP OPERATING CONDITION.

Distributors, located near all major oil fields in the United States and Canada, are well stocked with Bucyrus-Erie parts and tools and well staffed to help with spudder needs. And Bucyrus-Erie's own factory-trained operating engineers are available for on-the-job service.

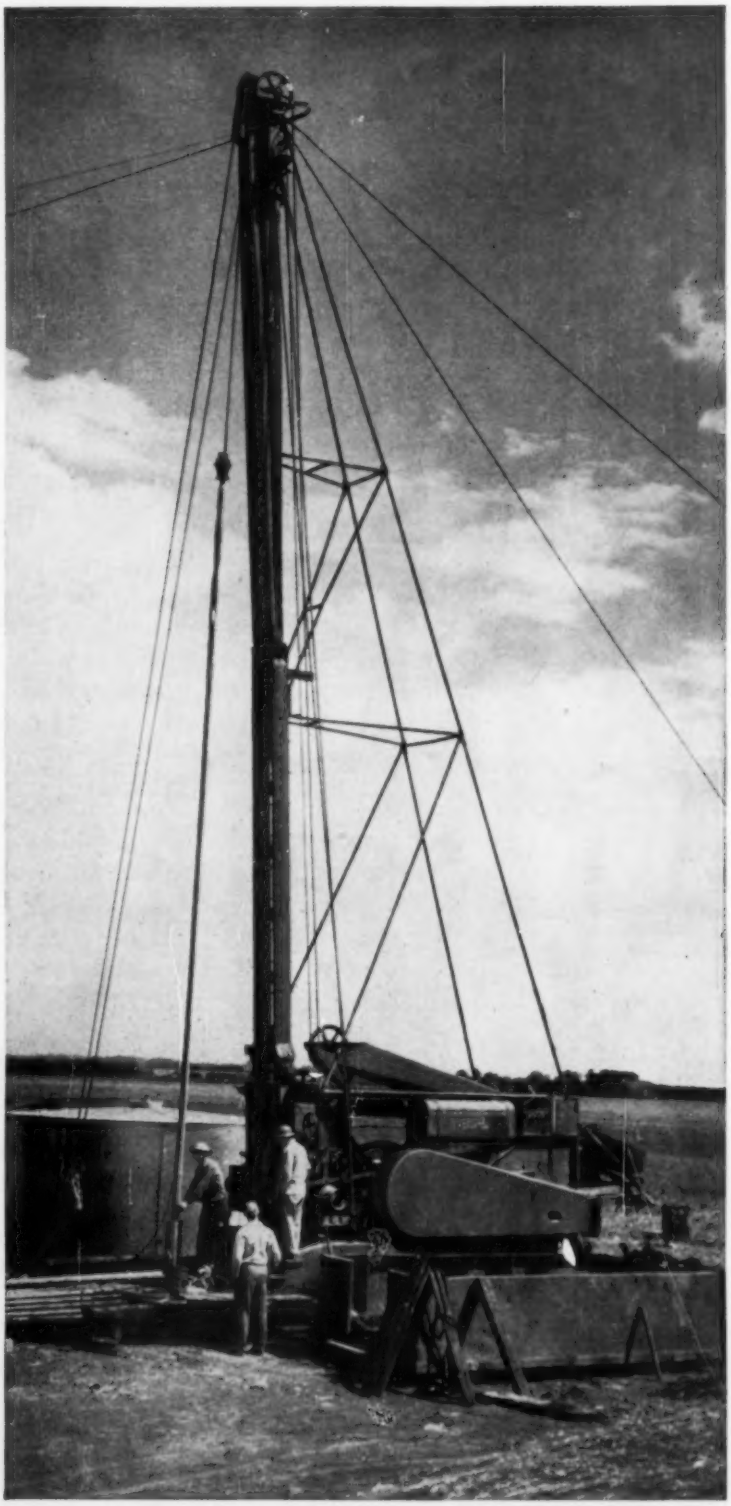
Get a quality machine backed by unmatched quality in service. See your Bucyrus-Erie distributor for the full story. 46557

BUCYRUS ERIE

South Milwaukee • Wisconsin

FIRST
with the FINEST
in SPUDDERS

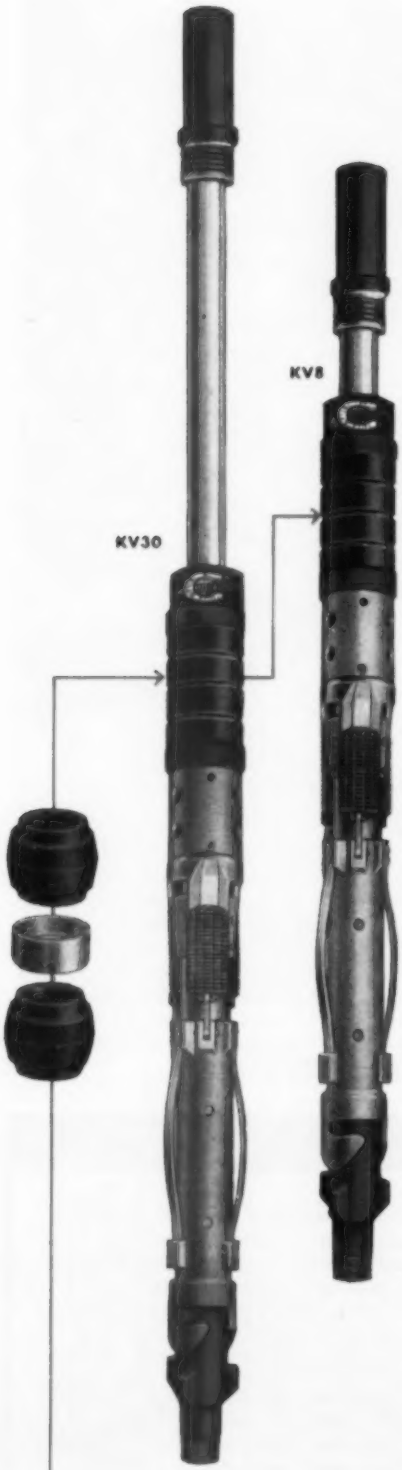
60-L * 28-L
36-L * 48-L



FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Durable and Dependable

GUIBERSON'S *KV* PACKERS



Two-piece G2 rubbers with metal spacer are interchangeable and optional at no extra cost. One-piece sleeve rubber shown on packers furnished unless otherwise specified.

Here is the retrievable packer that operators everywhere count on for rugged durability and dependable performance. The KV Packer is designed for wells up to 12,000 feet deep. Construction is as simple as it is tough and husky — price is reasonable. In short, the KV Packer gives you more packer for the money — quick setting, easy pulling, ample bypass and positive seal.

- Made as the KV30 with 30" valve stroke or the KV8 with 8" valve stroke for standard below-packer circulation. Available in casing sizes, 4½" through 9⅝".
- Valve has two independent sealing elements, a tapered metal valve and seat and a set of oil-resistant seal rings, affording double-sealed protection.
- Choice of two types of rubbers, both made of special oil and gas resistant compound. Will not vulcanize to casing — recovers original shape when released.
- Easy operating jay-hook type latch with heat treated friction springs.

THE
GUIBERSON
CORPORATION

ESTABLISHED 1919
DALLAS, TEXAS
U. S. A.

Sold by
Oil Field Supply Stores
Everywhere

WAUKESHA

Engines and Power Units FOR GAS COMPRESSORS

Typical Waukesha-driven compressor application (Model WAKU engine) in Southwest

● You can select exactly the right power to meet your gas compressor needs because the Waukesha Engine line is complete. All the proven features that give long engine life . . . the ability to withstand overloads . . . low upkeep and high economy of operation . . . are built-in. Materials, design and operating characteristics—all result from Waukesha's over 50 years of experience in fine engine building. You cannot buy a better compressor engine.

NATURAL GAS ENGINES FOR COMPRESSOR SERVICE				ENGINE	BRAKE HP. AT SPEEDS INDICATED							
Model	Bore & St.	Displ.	Installation	MAX. HP.	800	900	1000	1100	1200	1400	1600	1800
140-GZB	4⅛ x 5½	554	No radiator or fan	142 @	44	....	55	....	65	75	84	92
			With radiator, fan	1800	43	....	53	....	62	71	79	85
145-GZB	5⅜ x 6	817	No radiator or fan	214 @	65	....	81	....	96	110	125	139
			With radiator, fan	1800	62	....	77	....	90	103	116	129
WAKB	6¼ x 6½	1197	No radiator or fan	260 @	85	....	110	....	134	153	169	
			With radiator, fan	1600	82	....	106	....	127	144	157	
NKRB	7 x 8½	1905	No radiator or fan	335 @	155	170	187	203	218			
			With radiator, fan	1200	149	163	176	189	199			
LRORB	8½ x 8½	2894	No radiator or fan	465 @	228	250	268	283	302			
			With radiator, fan	1200	221	242	257	271	286			
LRZB	9⅜ x 8½	3520	No radiator or fan	568 @	273	304	330	351	369			
			With radiator, fan	1200	265	294	316	332	343			
VLROB	8½ x 8½	5788	No radiator or fan	890 @	435	481	524	557	579			
			With radiator, fan	1200	427	470	510	541	559			

65% ratings

NOTE: All models are 6-cylinder except Model VLROB (12-cyl.) and have aluminum pistons, counterbalanced crankshafts, and vibration dampeners.

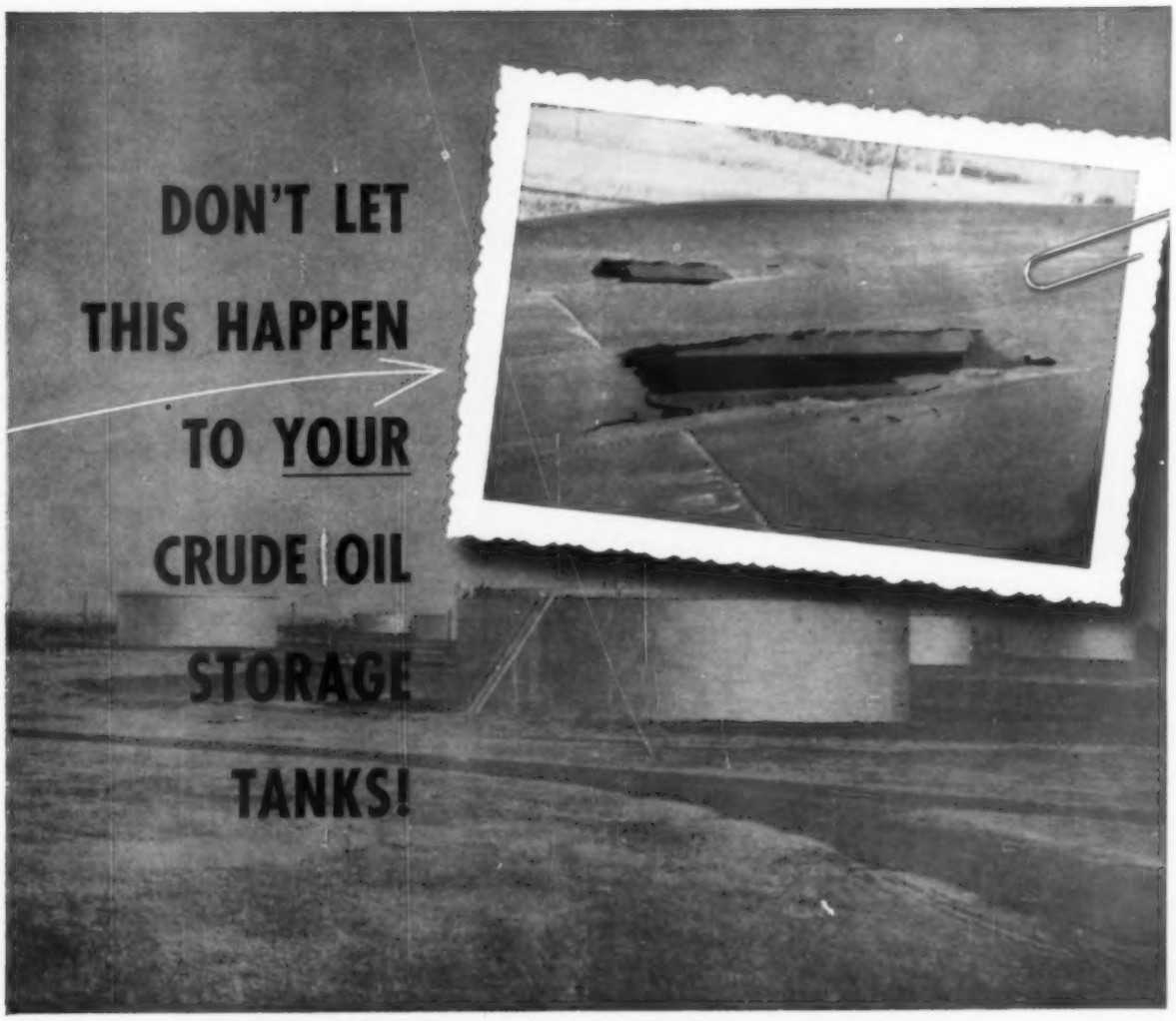
Send for descriptive Bulletin No. 1699

WAUKESHA MOTOR COMPANY • WAUKESHA, WISCONSIN

New York • Tulsa • Los Angeles

346-R

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD



Protect them with Pitt Chem TARSET®

RIGHT *now*—as you read this—corrosion may be destroying thousands of dollars worth of your petroleum handling and storage equipment. It happens every day, as witness the photograph of the crude oil storage tank top, above.

Now—for the first time—you *can* control these costly corrosion losses with a practical and relatively economical protective coating—Pitt Chem "Tarset." Backed by three years of service experience, Tarset combines the best qualities of two of industry's most effective and proven protective materials—*coal tar* and *epoxy resin.*

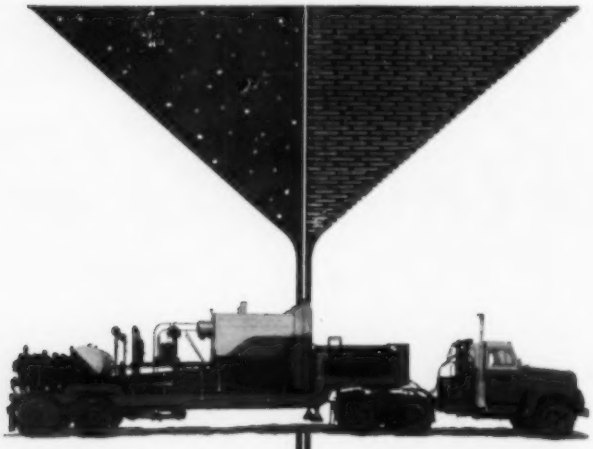
Tarset is the kind of a rugged, heavy duty coating you want. It will not shatter at −30°F or soften at 400°F.

It is easy to apply by brush, spray or roller and adheres so well that it is almost impossible to remove from metal.

What's *your* crude oil corrosion problem? Our Pitt Chem engineers are ready to tackle it right now . . . and, if possible, come up with some dollar-saving answers for you. *Write or call us today!*

WSW 6088A

COAL CHEMICALS • PROTECTIVE COATINGS • PLASTICIZERS • ACTIVATED CARBON • COKE • CEMENT • PIG IRON



WLC-1 IMPROVES

SAND | WATER FRACTURING

Now, through Halliburton's continuous research, you can take greater advantage of the unchallenged economy of WATER in certain fracturing situations.

Halliburton's remarkable new fluid loss control chemical WLC-1, added to fresh or salt water or oilfield brine in Halliburton's Sand-Water fracturing process, gives you these advantages:

- In creating fractures, fluid volume efficiency is increased.
- Pumping pressure generally can be lowered.
- More sand is carried farther into the fracture.
- Possibility of water damage and emulsification within the formation is lessened.
- Less sand returns to bore hole.

To know more about the increased effectiveness of Sand-Water fracturing with WLC-1, call your local office or write to the HALLIBURTON Oil Well Cementing Company, Duncan, Oklahoma.

Ask for your free Pumping Calculator

HALLIBURTON

OIL WELL CEMENTING COMPANY

PIONEERS IN FRACTURING SERVICES

251 SERVICE CENTERS—JUST MINUTES AWAY FROM ANY RIG

the LUFKIN formula

FOR SELECTING THE RIGHT PUMPING UNIT FOR YOUR WELL . . .

$$S_p = 35E + \sqrt{F^2 + M^2} + Q + P_e + f^{max}$$

E - EXPERIENCE, YEARS.

F - MODERN MANUFACTURING FACILITIES

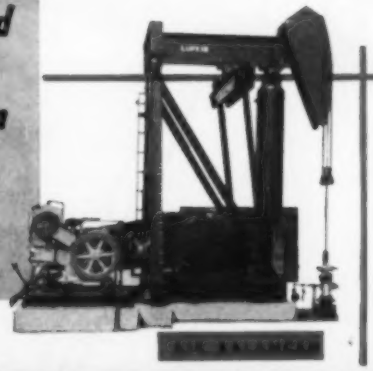
M - UP TO DATE METHODS

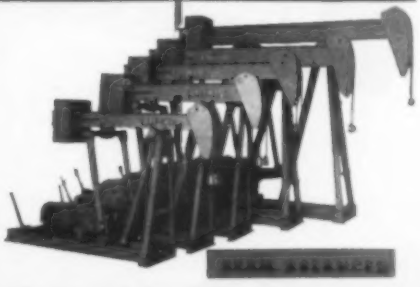
Q - BEST QUALITY MATERIALS

P_e - SOUND ENGINEERING PRACTICE

f^{max} - LARGE SAFETY FACTORS.

S_p - *SUPERIOR PUMPING UNITS*





There's always a standard LUFKIN unit with the right combination of beam capacity, counterbalance and peak torque for your well . . .

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Lufkin equipment in Canada is handled by
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BY BROWN

Parallel
Retrievable
Independent
Multiple-string
Equipment

PARALLEL STRING COMPLETION

Brown Oil Tools has several different types of retrievable parallel string packers for both dual and triple installations . . . tailor-made and field-tested for specific well applications. *For our new catalog on parallel string completions contact your Brown representative. Or write Brown Oil Tools, Inc., 8490 Katy Rd., Houston, Tex.*

BROWN
OIL TOOLS, INC.

N
12

TO HANDLE HEAVY HOISTING LOADS

...at maximum speed...with unusual economy

Reserve Powered **BREWSTER N-12**

Designed for rugged deep drilling service, the N-12 has exceptionally high mechanical efficiency over a broad depth range. Already proven on tough contracts from the Gulf of Mexico to West Texas, the N-12 has now set another new drilling record. The world's longest string of casing weighing 719,000 pounds has been run to 15,400 feet by Drilling Contractor Grady Roper with a Brewster N-12.

This example of **"RESERVE POWER"** in action again proves Brewster's known operating efficiency and economy. Compared feature by feature with other top quality drawworks, Brewster, you'll agree, is your best drawworks buy.

Write today for the new Brewster Equipment Catalog.

BREWSTER

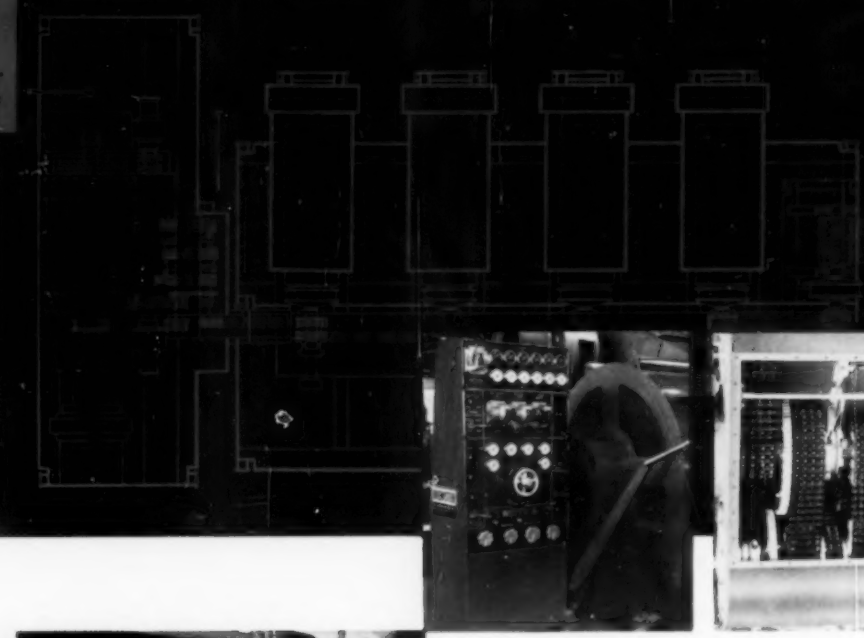
Reserve Powered

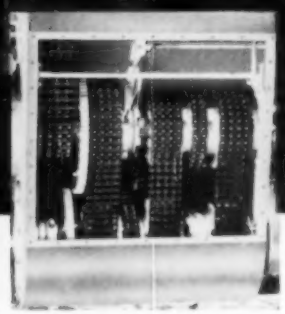
FROM DRUM TO PUMP DRIVES

N 12

Fingertip air controls – Full Horsepower at the drum – Chain transmission with four evenly graduated speeds and gear reverse – High and low clutches mounted outboard on main drum providing eight hoisting and two reverse speeds – Rotary drive with four forward and one reverse speed – Dual-in-line pump drives mounted at rear of compound – Choice of engine coupling including fluid coupling and torque converter – Heavy duty box type or sectional compounds for two and three level setups.

Power Layout





N-12 SPECIFICATIONS

Recommended Available h.p.	*1500*
Drum Brakes, Width and Diameter	*10"x54"*
Drum Core, Diameter and Length	*28"x54"*
Transmission Speeds	*4 forward & 1 reverse*
Overall Height	*7' 10½"*
Overall Width	*9' 5"*
Overall Length	*22' 10"*
Approximate Weight	*55,000#*

SUPPLY HOUSES

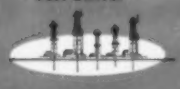
Howard Supply Company • Apex Equipment Company • Bovaird Supply Company • Industrial Supply Company • Murray Brooks, Inc. • United Supply and Manufacturing Company Export Sales: The Brewster Company • (HOMCO) Houston Oil Field Material Company, New York, N. Y., Houston, Texas; Mexico City, D. F.

Brewster Matched Equipment

Model 500 Traveling Block

8SX Swivel

RSH-27½" Oilbath Rotary



THE BREWSTER COMPANY, INC.
Shreveport, Louisiana

NORDBERG

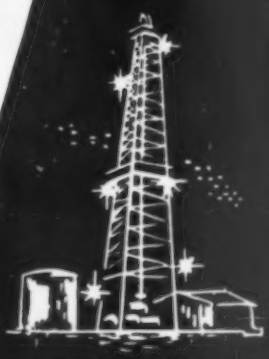
POWER CHIEF®

OIL FIELD ENGINES

FOR PRODUCTION PUMPING

Nordberg *POWER CHIEF* Gas Engines are low cost, medium speed units, ruggedly built for maximum economy on production pumping jobs where 'round-the-clock performance is a must.

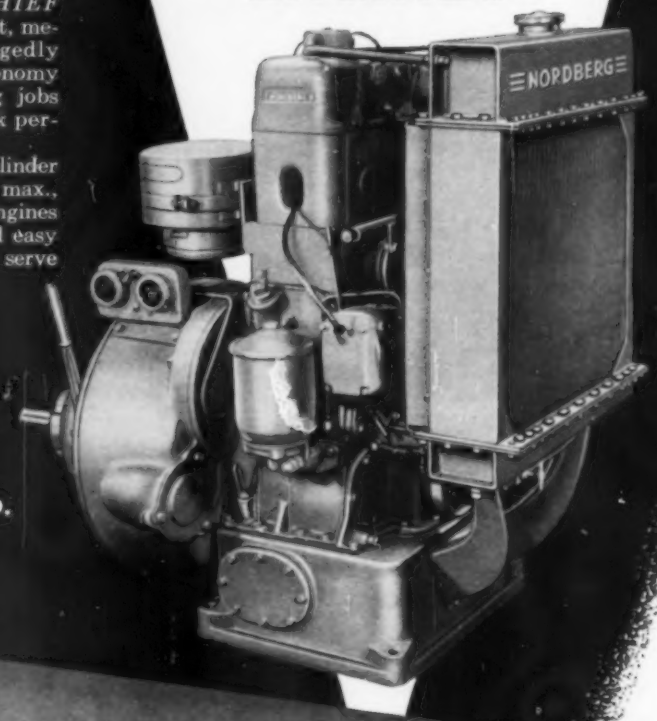
Available in 1 and 2-cylinder sizes, up to 36 hp max., *POWER CHIEF* Gas Engines are simple to install and easy to maintain—ready to serve you 24 hours a day.



FOR RIG LIGHTING

More and more rigs are being lighted by Nordberg *POWER CHIEF* Diesel Generator Sets . . . because these sturdy units stand the gaff of continuous service, night after night, without constant attention and maintenance.

Built in 1, 2 and 3-cylinder sizes, from 10 to 45 hp, 6 to 30 kw—*POWER CHIEF* engines are available with special vibration-proof mounting for rig installation



NORDBERG MFG. CO.
Milwaukee, Wisconsin

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POWER CHIEF DIESEL and GAS ENGINES

4-157-0

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BRANCHES: Houston, Odessa, Olney
SALES & SERVICE: Casper, Wyo.; Corpus Christi, Longview & Wichita Falls, Texas; Lafayette, La.; Wichita, Kansas.

IN-MAR CO., Wilmington, California

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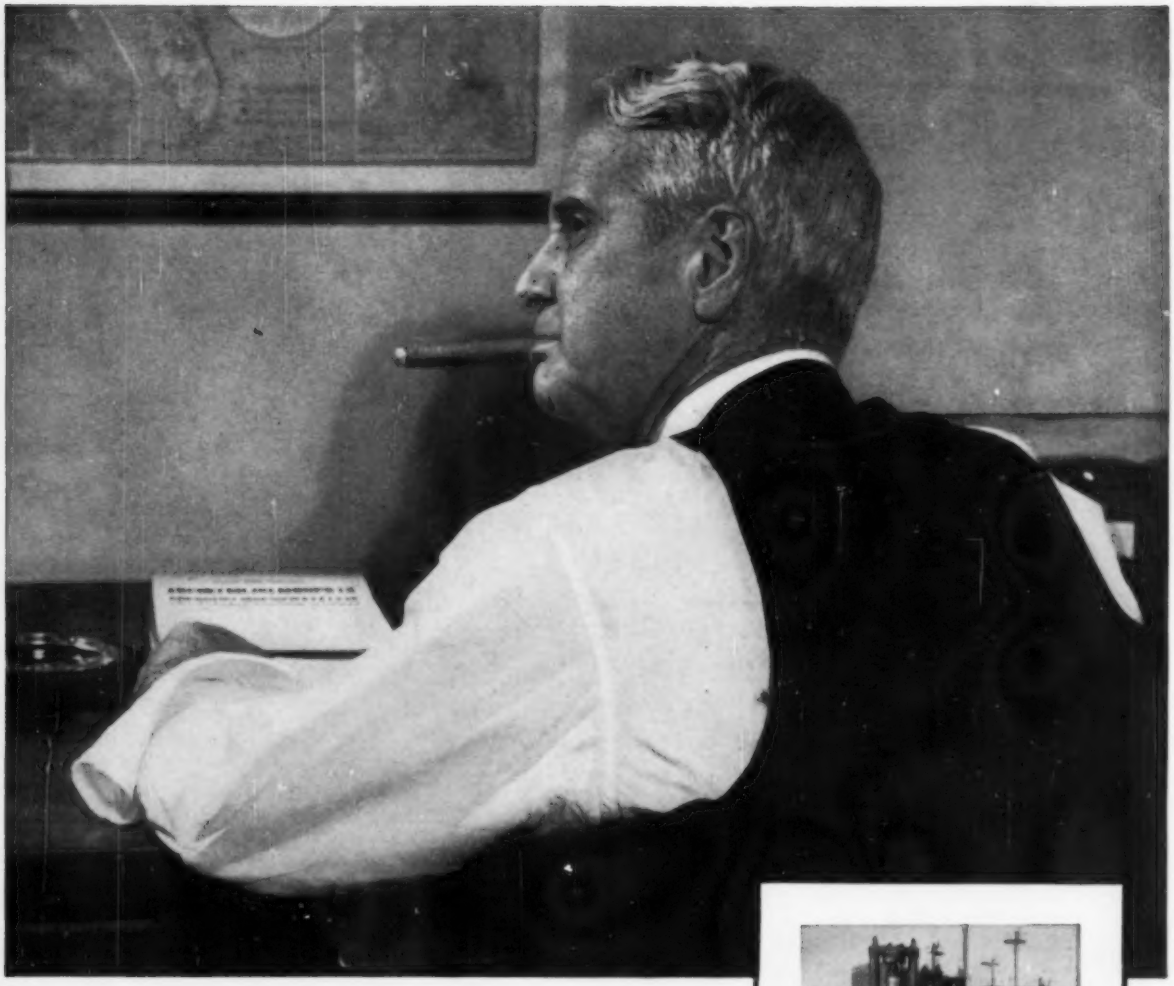

"And I say it has to be an ALDRICH PUMP!"

Continuous, heavy duty pumping operations, often at high pressures, demand the complete reliability and freedom from maintenance found only in an Aldrich Pump. Top performance under these conditions has earned Aldrich its reputation for building pumps of highest quality and dependability.

The tougher the job . . . the more important it becomes to take advantage of our wide experience in providing the petroleum industry with pumps for water flood, pipeline, gasoline plant, hydrocarbon injection or petrochemical service.

In the less critical jobs, too . . . it makes sense to call Aldrich. The simplicity of the Aldrich Direct Flow design, with fluid-end sectionalization and automatically controlled delivery, offers substantial economies in both operation and maintenance.

A copy of our new condensed catalog, showing the line of Aldrich Pumps is yours for the asking. Write for Data Sheet 100. The Aldrich Pump Company, 26 Pine Street, Allentown, Pa.

Shown above is one of a number of Aldrich 5" stroke, Triplex Pumps installed at a major west coast water injection project. These pumps are currently handling 35,000 bbl daily at injection pressures of 1,000 psi.

THE ALDRICH PUMP COMPANY

Field parts stock is available in Carmi, Ill., Charleston, W. Va., Houston, Texas, Los Angeles, Calif., Odessa, Texas, Tulsa, Okla.

. . . the best thing that can happen to Tool Joint and Drill Collar Threads

LO-TORK 50% PURE METALLIC LEAD BASE

NO-GALL 50% PURE METALLIC ZINC BASE

WECO COMPOUNDS

Failure of tool joint and drill collar threads can cause enormous expenses. Since so much depends on them it is imperative that they get the finest care and treatment possible.

An important part of proper care is the consistent use of **WECO NO-GALL** or **LO-TORK.** These incomparable compounds minimize friction . . . assure maximum gall resistance. They spread easily, uniformly – never gum up or squeeze out . . . never harden. Most important: they lengthen the life of tool joint and drill collar threads . . . . reduce down time due to thread failure.

Treat your tool joint and drill collar threads to the best – **WECO NO-GALL** or **LO-TORK.** Get them from your supply store.

C-4-55

WECO®

WELL EQUIPMENT MFG. CORP.
HOUSTON, TEXAS

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HOW TO GET ACCURATE INFORMATION IN CONSOLIDATED FORMATIONS

The *New* Schlumberger Combination Induction-Electrical Log

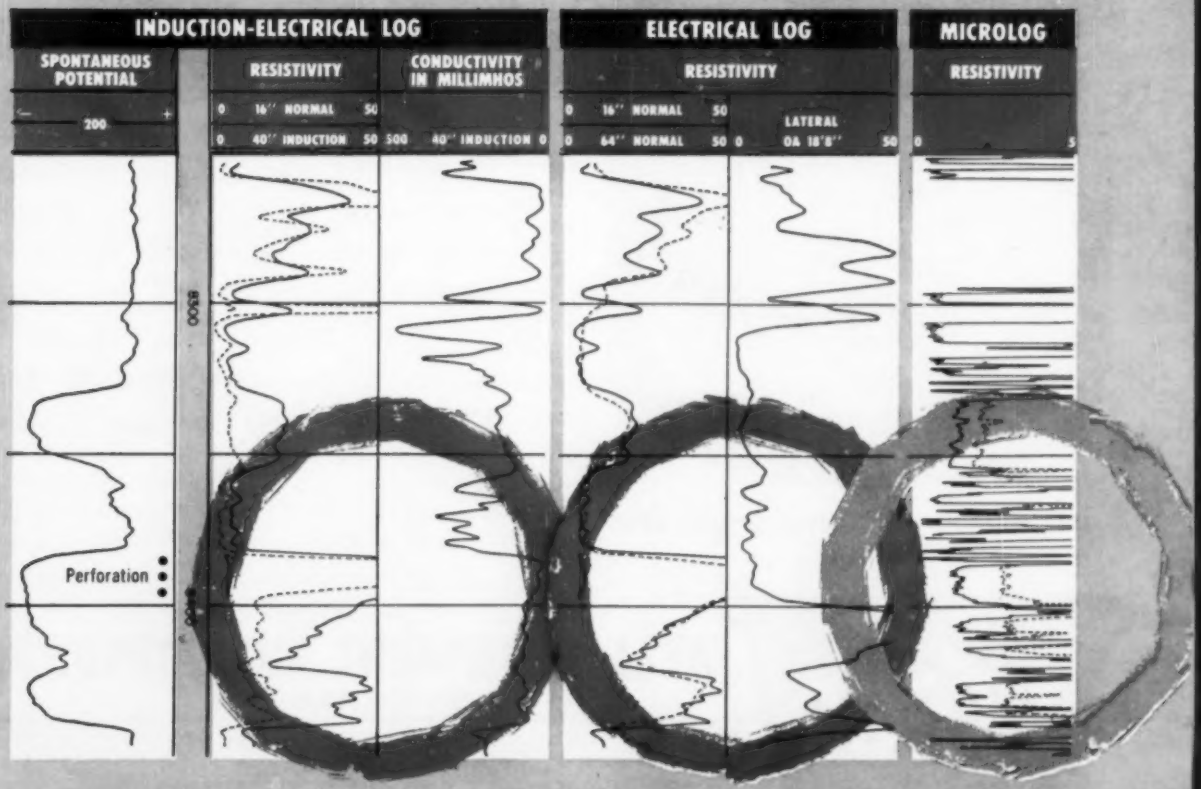
Sees More – Tells More

This example portrays the superiority of the Induction-Electrical Log in consolidated formations.

From top to bottom can be seen—sharp resolution in bed definition, penetration past the invaded section and curves with no distortion due to hard streaks or electrode spacings.

The producing section—is particularly outstanding because its limits are shown so clearly on the Induction Log while the electric log is difficult to interpret.

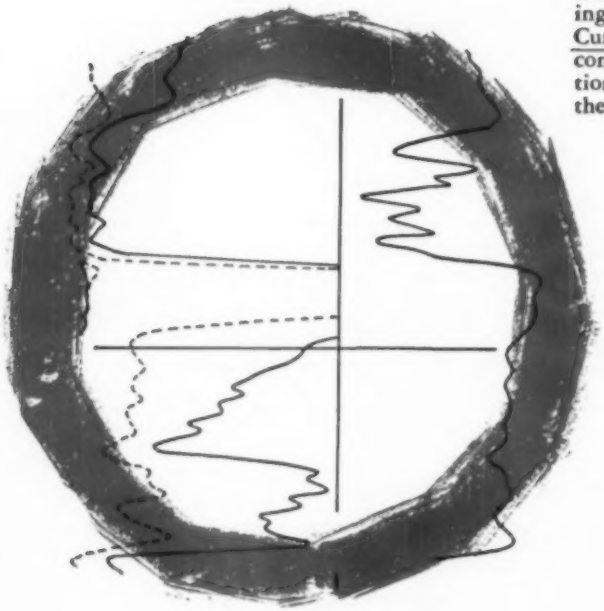
The perforated interval–produces 2.3 million cubic feet of gas per day with 20 bbls. of distillate per million.

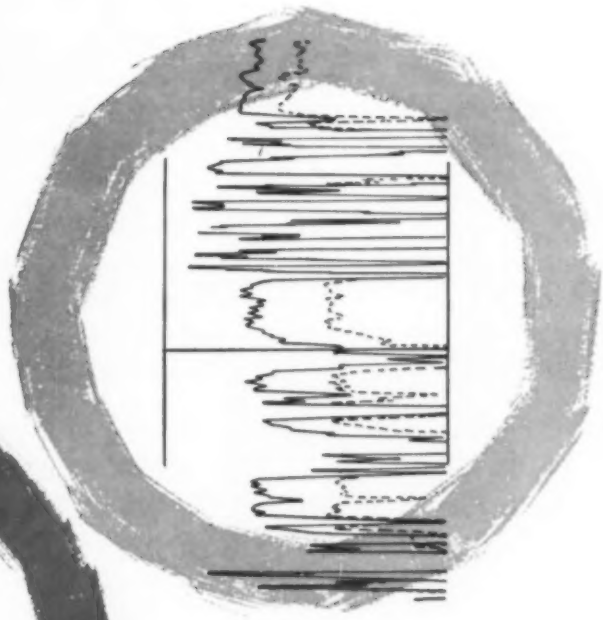


a major advance in well logging by Schlumberger

Formation evaluation

On the Electric Log, the sand is marked by high readings on the Short Normal, Long Normal and Lateral Curves. However, only the Induction-Short Normal combination clearly indicates the water-bearing section. The water level is well defined by the drop on the Induction Curve.





The high readings on the Short Normal and Long Normal Curves are the result of invasion. The lateral curve does not show the productive section at the top of the bed due to its characteristic lag. The lateral also gives high readings and misses the water in the lower section because of numerous hard streaks as shown by the MicroLog.

YOU CAN
PUT YOUR FINGER
on Why
WILSON SUPPLY SERVICE
is Better

Time after time a contractor driller or lease man is caught in a bind — and needs a piece of equipment, some repair parts or a service man quickly. Over the years he has found that Wilson Supply Company can and will meet his needs.

"What you want — when you want it" means more than a "delivery service" at Wilson Supply Stores. It means the complete cooperation of a skilled personnel with those men who drill the wells and produce the oil.

"WHAT YOU WANT — WHEN YOU WANT IT"

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DALLAS — SHREVEPORT — SAN ANTONIO
TULSA — NEW ORLEANS — LAKE CHARLES
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WILSON SUPPLY CO
HOUSTON, TEXAS

Bill Brandon, second from left, D&S engineer in Iraq in charge of coring operation, H. C. Bell, fourth from left, Mercer Martin, driller, extreme left, and crew on Iraq Petroleum Company Well Number 116.

New D & S Diamond Bit Solves Coring Problem in Kirkuk, Iraq

- D&S bit gives first large-scale core recoveries of 93%.
- New D&S bit allows substantial savings over previous methods.
- New core bit exceeds all Kirkuk penetration rates.

Twenty-four-year-old Kirkuk oilfield in Iraq . . . scene of new field-proven techniques using Drilling and Service's revolutionary Tri-Dia bit . . . witnessed an unprecedented 87 percent core recovery compared to previous core recoveries of 18 percent.

Cores needed for reservoir study of the Kirkuk field became D&S's assignment, when standard coring methods failed to give adequate recovery of samples from the tricky limestone. After reviewing the available information on earlier techniques used and the formation to be cored, the D&S engineer traveled to Iraq to design a diamond bit and develop techniques on the spot that accomplished high core recoveries of the 1,459 feet of Kirkuk's highly fractured and porous productive limestone, making available the reservoir information for the first time in the history of the field.

LARGE SAVINGS OVER PREVIOUS METHODS

A cost analysis of Drilling & Service's new diamond Tri-Dia core bit showed substantial savings over previous wells cored with conventional bits and drilling equipment. D&S's Tri-Dia Core Bit, because of its unique 3-cornered design allowed more free movement of mud circulation removing the hazard of sticking the drill string common to the area due to fractured formation falling into the hole. Former drilling, with either water or degassed crude oil and conventional bits, produced cuttings so large that they screened out to accumulate in the hole. The new Tri-Dia Bit reduces such cuttings to powder . . . a reduction which can be received into the formation when drilling without circulation.

FASTEST RATE OF PENETRATION

The second well, now being cored with D&S Diamond Tri-Dia bits, reveals a rapid rate of penetration in its early stages. Core recoveries of 93 percent are now being obtained, due to further development of the operational techniques. This well, planned for deep test, is cutting a 10⅝" OD Tri-Dia Diamond Core Bit hole to accommodate a large string of casing through the Kirkuk limestone to allow the use of heavy mud if necessary to control expected high pressures.

D&S WHIPS FORMATION PECULIARITIES

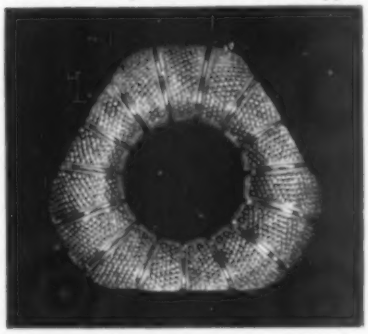
The Iraq oilfield . . . with oil production over the past 24 years at rates up to a half-million barrels a day . . . is 68 miles long, eight miles wide, and has an effective pay thickness in excess of 1200 feet. The flaming fires . . . twenty centuries old . . . located near the center of the huge structure and visible at the surface, are fed with gas seepage through the formation's many crevices and fractures. The Kirkuk reservoir, which acts like a huge underground tank of oil, reflects similar pressure throughout the field, indicating complete communication due to fractures.

This monstrous reservoir, until the recent introduction of D&S Tri-Dia Bits, allowed but a minimum of core information. All previous methods of coring encountered considerable trouble because of the highly fractured and porous characteristics of the Kirkuk limestone.

CORE RECOVERIES ESSENTIAL TO CONSERVATION

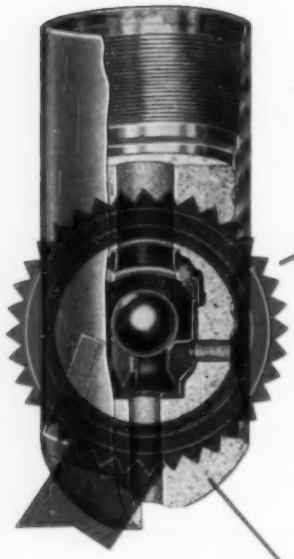
Operators of the field are strong exponents of conservation and of obtaining the ultimate recovery from their oil reserves. To accomplish this goal, they are initiating a program using the most modern equipment and methods designed especially for their reservoir. Drilling & Service plays a major part in this program.

Drilling & Service Incorporated, often called upon to solve various types of coring problems throughout the world similar to that of Kirkuk, specializes in custom design for each coring and drilling operation. Write or call today. A D&S sales-engineer will call on you and explain the many advantages of the new revolutionary diamond Tri-Dia coring and drilling bits. D&S sales offices are located in major oil areas. Home Office: 6210 N. Central Expressway, Dallas, Texas. (Adv.)



The new D&S Tri-Dia Bit, pictured above, features built-in engineering and advantages never before achieved in a coring bit.

Through the years...
today and for many tomorrows...



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PROTECT YOUR INVESTMENT IN TIME AND EQUIPMENT AND RUN FLOATING EQUIPMENT THAT OFFERS PROOF OF PERFORMANCE AND DEPENDABILITY. THE PROVEN ADVANTAGES OF THE BAKER BALL-TYPE BACK-PRESSURE VALVE FEATURING THE SEAL OF PERFECTION CAN BE YOURS BY MERELY SPECIFYING BAKER FLOATING EQUIPMENT.

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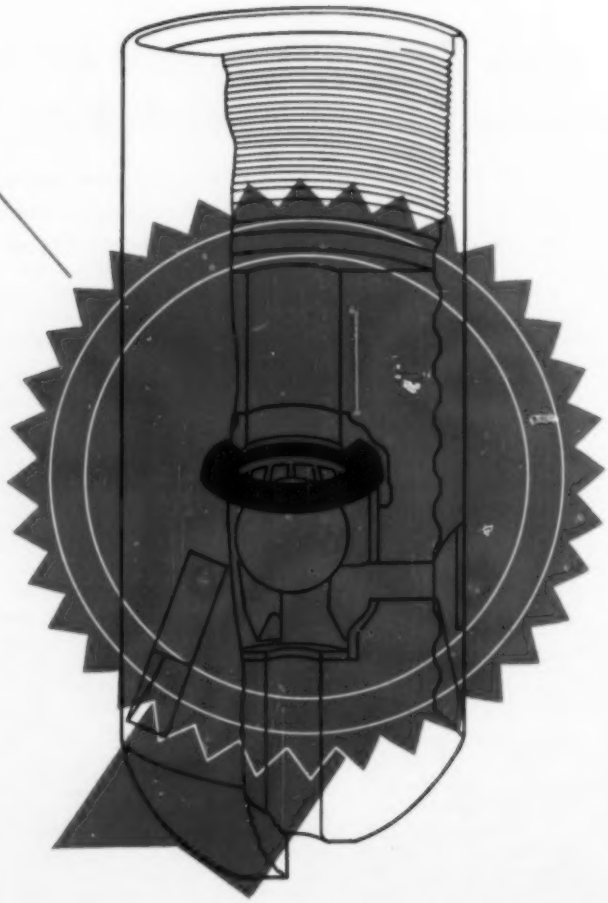

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Dry hole money . . .

The Fair Contribution

Here are six basic principles which help determine the fair burden in dry hole contributions

John H. Folks
Division Landman,
The Carter Oil Company

THERE are certain features concerning dry hole contributions under serious consideration today which should result in more uniform thinking. If accepted, these would serve to curtail the greed which exists in all of us, so that more advantageous contributions may be granted and received with the end result that more deals will be consumated.

This is being made in the belief that the "sharp trading" days are rapidly vanishing. There appears everywhere a clearly defined trend that the vast majority of management wants to bear the true burden in acreage evaluation.

Underconsideration for use in arriving at fair contributions are six "yardsticks." The usage of these and the inequities involved in three traditional committments are discussed here.

1. Circle Method

This is frequently referred to as the Proximity System. It consists of a series of circles, the first being of sufficient size to embrace one drillsite; three additional ones exist, each covering an area two drillsites greater in diameter than the former. The contribution to be borne by any tract of drillsite size which is traversed by more than one circle is determined by that circle which includes the greater portion of the tract.

This method takes no cognizance of structure, faults or any other technical data; neither is any credit given for any acreage lying outside the scope of the largest circle. The amount of money to be borne by each tract is determined by its geographical distance from the proposed location (Fig. 1).

In applying this method, 50 percent of the dry hole cost is charged to the owner of the well simply because of the well's ownership. It should be pointed out that this is somewhat arbitrary, since the area covered by the inner circle includes only one drillsite, the assessment should be the national pool dry hole risk ratio, which approximates only 30 percent. The risk of drilling a dry offset to the first well is, of course, the reason for assessing a larger proportionate part of the drilling cost to the owner of the tract on which the first well is located.

The owners of the eight tracts (quarter quarter sections in this instance) which tracts are embraced by the second circle, bear 25 percent of the total dry hole risk. Each drillsite, therefore, bears $3000 dry hole money.

The owners of all drillsites within the third circle bear 15 percent of the cost, a total of $14,400. Within the circle there are 12 tracts which participate equally in the cost so that each tract bears $1200.

Ten percent ($9600) is borne by the owners within the fourth circle. This circle contains 16 participating tracts and each tract, therefore, bears $600.

As is generally the case, this system compels the drilling party to pay or bear that part attributable to any tract which, either because of being unleased or because its leasee owner refuses to support, does not bear its burden.

2. Square System

This again is a proximity method and in principle is the same as the circle method. This system consists of a series of four square rectangles (Fig. 2). The first will embrace only one drillsite. Each additional one will be two drillsites greater in width than the former. This "yardstick" is more easily employed than the circle method since no tract is traversed by more than one rectangle.

The owner of the drillsite bears 50 percent of the cost plus, of course, that part attributable to any tract which does not bear its part. Each of the eight tracts within the second rectangle bears 3 percent of the cost. Those within the third rectangle each bear 1 percent and those within the fourth rectangle 25 percent.

A mechanical tool can easily be made and employed for using the square system as a basis of computation. On any transparent material place light colored lines so that quarter quarter sections can be outlined. A scale of two inches to the mile is quite practical. Bold lines should be drawn to delineate the four rectangles. By marking in one's holdings on a work sheet plat of the same scale as the tool and then by placing the tool over the plat, the appropriate percent of cost for each tract will be instantly apparent. The total contribution will consist of the sum total of the percentages multiplied by the total dry hole cost.

Those technical considerations normally prevalent in arriving at a fair contribution are in no manner considered. The question of how much or how little acreage the contributing party has outside the square is unimportant. Those objections which prevail both in the circle and square methods quite generally prevent a literal application of either. While strict application will often result in worthless acreage bearing a share of the cost which the usage of available technical information would prevent, by the converse, some application of either will normally result in a contribution being made which, because of the total absence of technical information, could not otherwise be granted.

3. Adjacent Quarter Section System

A method which some contend to be fair, particularly in areas of little control and universally small fields as exist in Kansas, Eastern Oklahoma, Illinois, Indiana, and Kentucky, is the "adjacent quarter section system."

This method requires the owners of the well and the quarter section on which the well is located to bear ½ the dry hole cost. Each of the three offsetting quarter sections bear ⅙. The owner of the inside 80-acre tract in each quarter section pays twice that of

Presented as an address before the American Association of Petroleum Landmen at San Antonio, Texas, April 26, 1957, and published here by special permission.

the outside 80-acre owner. In event the owner of the well owns less than the quarter section on which the well is located, the owner bears ⅓ of the cost for the well's ownership and the owner or owners of the remaining portions of the quarter bear the ⅙ in proportion as they own in the remainder of the drillsite quarter. Referring to the illustration (Fig. 3) it is observed that Able plans to drill a well, the dry hole cost of which is $24,000. Able owns the SE/4 Section 9 and will, therefore, bear $12,000 of the cost. Baker owns the S½ NE/4 Section 9 and since this is an inside 80-acre tract, Baker will bear ⅔ of the ⅙ of the cost, or $2670. Charley will contribute ⅙ for the NW/4 and ⅓ of ⅙ for the N½ NE/4 Section 9, a total of $5330. Dog will bear $2670 for the N½ SW/4 and $665 for the SE SW Section 9, a total of $3335. Love will bear ½ of ⅓ of ⅙ for the SW SW, a total of $665.

Inasmuch as the adjacent quarter section method is one of proximity, all of the objections prevailing against usage of the circle and square systems may likewise be asserted against employing this system.

4. Proportionate Part of Structure or Anticipated Producing Area

This method is the complete converse to the circle and square systems. Proximity is totally disregarded. Technical data determines wholly the contribution. The contributing party is the sole judge as to the geographical confines of the producing structure. He may select only the top closing contour for an outline or that one which he believes will define the oil/water contact.

He who insists upon using this "yardstick" will frequently invite the soliciting party to show evidence of the ultimate producing area as a prerequisite to a contribution, or he may simply advise that he, or his company, does not have evidence of a trap and hence cannot support with cash.

Once, however, the contributing party has concluded as to the size of the ultimate producing area, he determines the contribution by first deducting 50 percent of the dry hole cost which is to be borne by the owner of the well and drillsite. (Fig. 4.) He then determines the total remaining acreage within the producing area and the percentage thereof which he owns. His percentage is multiplied by ½ the drilling cost and the result is the correct contribution.

Once again should any owner refuse to support, his interest is borne by the drilling party.

The folly of this system seems to lie in its failure to recognize proximity. Failure to do so denies the existence of that well-established dry hole risk in pool well development. Obviously those owners of tracts on the edge, such as Able, should not be required to bear the risk of two intervening wells while Charley bears only one, unless the edge owner is to stand initially less of the dry hole cost.

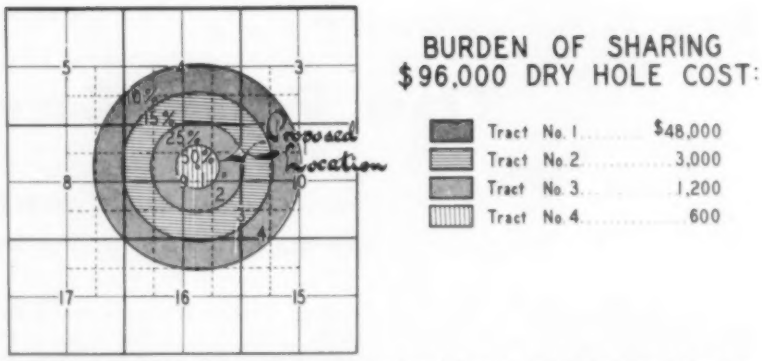


Fig. 1. Circle method of computation, often referred to as the proximity system in determining dry hole contributions. This system does not consider structure, faults or other technical data.

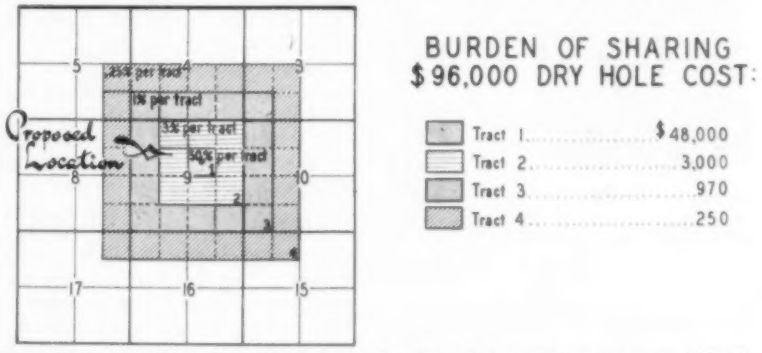


Fig. 2. Square method of computation is another form of the proximity system, and like the circle method, does not consider structure or technical data.

5. The Nine Section Pattern

In areas for which gas is the primary objective and 640-acre spacing is universal and where little technical control exists, such as in Texas and Oklahoma Panhandles and in Southwestern Kansas, a feeling is shared by some that the owner of a well and the 640-acre drillsite should bear ½ the dry hole cost and the owners of the adjacent eight sections should bear the other half. If the drillsite section be owned by more than the drilling company, each of the owners including the drilling company pays in the ratio that his ownership bears to the section times ⅓ the cost of the well. The owner of the well will bear ⅙ of the cost plus the additional cost chargeable to his lease ownership. The ⅙ cost to the owner is charged because of the possibility that the well may be completed as a producer of oil, in which event the drilling company would own all of the well. Each owner within the drillsite section participates in an agreement which permits him to share in proportion as he owns in the section in any gas well that may be completed upon reimbursement for a like amount of the total cost of drilling and completing a well.

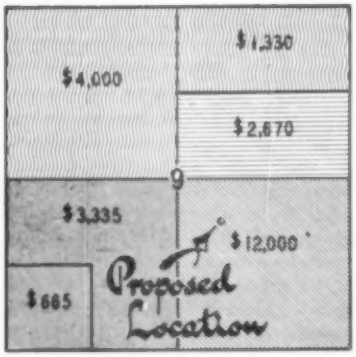
Since only one well will be drilled in each offsetting section, there is no advantage to being on the inside in the offsetting sections and, therefore, the owners in each offsetting section pay in proportion as they own in the section.

In the illustration (Fig. 5), Able bears ⅙ of the cost because of ownership of the well plus ½ of ⅓ for ownership of the E½ Section 9. The two components are expressed as "⅔ of ½." In addition, Able bears 1/32 of ½ for each quarter section it owns in the eight offsetting sections, a total of 6/32 of ½, and, as is always the case, the drilling company must carry the open acreage, so Able bears an additional 1/32 of ½ for the SE/4 Section 3 which is unleased. In all, Able bears

The Author

John H. Folks is division landman for the Carter Oil Company's North Arkansas, Oklahoma, Kansas, Southern Nebraska and Missouri areas. He is a graduate of the University of Oklahoma School of Law and is a member of the Oklahoma Bar. With the exception of service with the army during World War II, Folks has been with Carter since 1936. He has served in the Land Department in the company's southern, eastern, and central divisions.

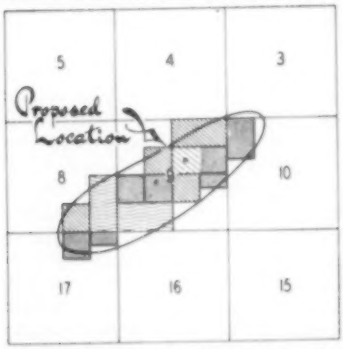
During the years 1953 to 1956 he served as Chairman of the Industry Steering Committee during the time the committee compiled and published the widely used Model Form Operating Agreement.



BURDEN OF SHARING
$24,000 DRY HOLE COST:

ABLE	50%	$12,000
BAKER	11%	2,670
CHARLEY	22%	5,330
DOG	15%	3,335
LOVE	2%	665

Fig. 3. **Adjacent quarter sections** method is considered by many as a "fair system" in areas of small fields as exist in Kansas, Eastern Oklahoma, Illinois, Indiana, and Kentucky.



BURDEN OF SHARING
$100,000 DRY HOLE COST:

	COST PARTICIPATION		PERCENTAGE OWNERSHIP
ABLE	50%	$50,000	Not Applicable
ABLE	6%	6,500	13%
BAKER	16%	16,100	32%
CHARLEY	15%	14,500	29%
DOG	13%	12,900	26%

Fig. 4. **Proportionate ownership** method is converse in theory from the circle and square systems, as proximity is entirely disregarded. The contributing party is the sole judge of limits of the producing structure.

$44,260.

Baker contributes ½ of ⅓ for the W½ Section 9 plus ⅛ of ½ for Section 8, a total cash contribution of $22,960 for which Baker gets the right to participate 50 percent in a completed gas well at cost.

Each of the other owners in the offsetting sections pays 1/32 of ½ for each quarter section of ownership.

6. Per Acre Basis

This, bye and large, seems to be one of the most widely used of all the "yardsticks." An operator arbitrarily agrees to pay a specified sum for each acre that is evaluated. This sum may be set on a tract-to-tract basis, or for all acreage in a township, county, or geological province. The contributing party, of course, decides the amount of acreage that is being evaluated. In the minds of many there seems to be concern that only acreage which is directly offset can be considered as evaluated. Perhaps a much fairer approach is to first exploit all known technical data in possession of the contributing party, and if this does not define specific limits, to then employ one of the proximity methods discussed earlier.

In Fig. 6, Love considers all of its acreage as being tested and contributes $10 per acre, but concludes that the NE SE of Section 3 is not being tested. Dog follows traditional thinking and declines all support since it has no direct offsetting acreage.

Many of the companies that use the per acre basis first determine a gross sum and then convert the sum into a per-foot-of-drilling unit. The ease with which this method can be applied, coupled with the emphasis which it places on pecuniary benefit to the contributing party, probably accounts for its widespread usage.

Traditional Contribution Inequities

There are several inequities in the three traditional contributions to be considered. In Fig. 7 Good Company proposes to drill a test of sufficient depth to test the Arbuckle, unless production, 6000 ft, granite or impenetrable substances be encountered at a lesser depth, and in support therefor receives three traditional commitments:

(A) **Fixed sum dry hole contribution.** Able commits $10,000 provided the well is abandoned as a dry hole 120 days from commencement of drilling. This type of contribution makes possible situations as follows:

1. Good drills to a depth of 3000 ft and hits a granite boulder, following which the well is abandoned. Although neither company anticipated this occurrence, Able is required to pay the full $10,000. This sum of money represents approximately 70 percent of the expenditure incurred by Good, although at the inception both companies intended that Able bear only 16 percent of it. Obviously, alertness on the part of Able would have averted this embarrassing occurrence.

2. Good drills to the total depth and finds the Arbuckle dry. Although the Mississippian was of poor quality, Good feels there is a chance of making a small well which would return more than enough to pay the $28,000 required for completing the well. Good requests Able to convert its dry hole money to bottom-hole money in order that pipe may be run. Able concludes that, while undoubtedly Good has the situation correctly analyzed with regard to profits, nevertheless, it must not violate tradition and establish a policy which will open the door to argument on every dry hole commitment in which a well of questionable capabilities is to be completed. Good concludes its profit picture would be better to accept the dry hole contribution and forego the opportunity of possibly completing a small well which might lead to more development.

3. Good drills to a total depth and incurs an expenditure of $60,000. At a depth of 2000 ft an excellent Permian show is had. Good completes the well as a producer and then asks Able for the sum of $6600 being the prorata drilling cost below the Permian. Able replies that its commitment for a contribution was predicated on the well being abandoned as a dry hole. Clearly, the intent of the parties was that Able share in approximately 16 percent of the drilling cost below the Permian. Yet, because of tradition which prevented appropriate negotiation of true intent, Able bears none of the $6600 which it justly owes.

(B) **Stipulated sum per foot of drilling.** The flexibility afforded by this method tends to minimize some of the inequities which exist in the fixed dry hole contribution.

1. In event Good encounters granite at a depth lesser than the objective and is forced to abandon, the per foot sum will result in Able paying more nearly in proportion as was intended by the parties than in the case of the fixed sum.

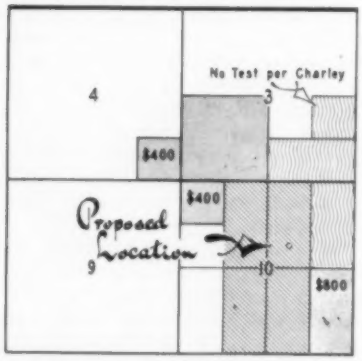
2. Should Good complete in the Mississippian or Permian, and Baker desire to pay for the deeper drilling for which it has received benefit, the per foot of drilling establishes a satisfactory sum to both parties which can be consummated with a minimum of negotiation.

3. Should Good drill to the agreed upon stop depth of 6000 ft without having reached the Arbuckle, the per foot formula makes for ease in extending the depth although increasing the

BURDEN OF SHARING
$100,000 DRY HOLE COST:

ABLE ⅔ x ½ + 9/32 x ½ + 1/32 x ½	$44,260
BAKER ⅓ x ½ + ⅛ x ½	22,960
CHARLEY 7/32 x ½	10,920
DOG ¼ x ½	12,500
LOVE 9/32 x ½	9,360

Fig. 5. **Nine section pattern** method is used in natural gas objective areas and 640-acre spacing areas and where little technical control exists, such as in Texas and Oklahoma Panhandles and in Southwestern Kansas.



BURDEN OF SHARING
$24,000 DRY HOLE COST

LOVE	$10/Acre	$ 1,600
CHARLEY (for acreage evaluated)	$15/Acre	$ 2,400
DOG — Gives Nothing	—	—
ABLE (Drilling Company)		$17,600

Fig. 6. **Per acre basis** for figuring dry hole contributions is perhaps the most widely used method. An operator arbitrarily agrees to pay a specified sum for each acre that is evaluated.

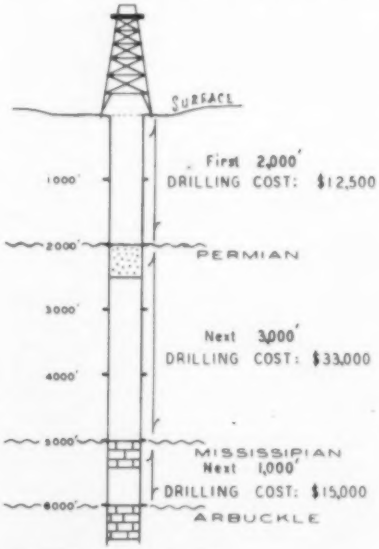
per foot price is normally at this point in order.

4. Should Good complete a producer of gas in the Permian or Mississippian and the contribution letter contain a "back-in provision into such gas well at cost of drilling to and completing in the productive formation," the per foot basis of cost lends itself to easy negotiation should Baker desire to pay in addition to the back-in cost, for the non-productive drilling below the formation in which the well is completed.

(C) **Assignment of all rights in leaseholds or portions thereof.** Although in the case of a cash contribution most of the advantage is with the contributing company, such is not the case in the matter of acreage contributions. This type of contribution distinctly differs in that the contributing company assigns the acreage whether the well be completed as a dry hole or producer. The traditional agreement gives assignee many rights to which there is much question as to whether he is so entitled, some of which are:

1. In event Good finds the Permian productive, it may complete the well and under the traditional agreement receive an assignment of all rights. Clearly, the Mississippian and Arbuckle have not been tested as was the intent of the parties. Some companies would insert a proviso which would reserve all rights below those tested. In the event of such an attempt, the technique to be employed in each instance must be thoroughly considered. In areas of gentle relief and thick formations, such as those of thick Mississippian which contain possible productive horizons throughout the formation, Good can more nearly accomplish equity by reserving rights below the depth drilled, otherwise a mere penetration of the formation may result in Charley being assigned hundreds of feet of potential production on which there has been no test. On the other hand, in areas of steep dip a reservation of rights below the depth drilled may result in severe complications. In one case involving steep dip, Charley assigned rights down to 4000 ft to Good. Later development demonstrated that production on the same lease could be had from one portion above 4000 ft and on another portion below 4000 ft. Yet, all the production was from the same reservoir. In this case, the court held that Good owned all the reservoir and Charley was forced to shut-in wells which were taking production from it. Charley in the future will, of course, avert such unfortunate occurrences by assigning to the base of the deepest formation tested.

2. Equity in rental obligations. In those cases in which Charley reserves deep rights, however expressed, fairness also dictates a proviso which causes each company to share in rental payments. Normally the assigning company continues to pay delay rentals since it has necessary records already set up.



OPERATOR: Good Co.
OBJECTIVE: Arbuckle or 6000 ft or Production or Granite
COST: Dry Hole $60,000; Completed $88,000
CONTRIBUTIONS: Able $10,000 DHM; Baker $1.00 per ft DHM; Charley 160 acres

Fig. 7. **Proposed well,** as shown here, points to inequities in the three traditional contribution methods.

Picking the Method

Of the listed six "yardsticks," namely: The circular method, the square system, adjacent quarter section, proportionate part of the structure, nine section pattern, and the per acre basis, none can normally be used in itself, but a consideration of those appropriate will give consolation to him who in his heart desires to be absolutely fair and a like application by the recipients will assure him that the contributing party has been abundantly fair.

Management demands that we stray from the paths of our fathers urging that we use all the "yardsticks" coupled with any others which may become known to us. Management is entitled to protection from the inequities which are contained in normal contribution letters. Keen foresight and negotiating ability, properly utilized with a keen sense of fairness will truely bring about the fulfillment of a law which precedes our industry by many decades — "Do unto others as you would have them do unto you." ★ ★ ★

Choice of a . . .

Water Supply For Waterflooding

Donald E. Menzie,
Associate Professor of Petroleum Engineering, The University of Oklahoma, Norman, Oklahoma

Survey points to:

- ***Doubling water requirement demand for flooding purposes in next 10 years***
- ***Number of brine floods increasing, number of fresh water floods decreasing***
- ***New and numerous combinations of water source and type possible***

RELIABLE investigators have estimated that within the next decade water requirements in oil production will double. Paul Torrey[20] in 1956 stated that a total of 5½ trillion gal of water would be needed to recover the waterflooding reserves of Texas alone. The growth of water flood application necessitates an evaluation of water supplies for this purpose. In any area water availability should be studied extensively before a water supply is chosen. While some areas offer a choice, in almost all areas at least one source of injection water can be developed.

SURVEY OF WATER SOURCES

There are two problems in selection of a source of water supply for waterflooding operations. (1) Selection of the best source and amount of water. (2) Selection of the best treatment to make the water suitable for injection. Good raw water requires less treatment and produces a more stable injection fluid.

Volume Required (Quantity)

A satisfactory quantity is of course a first consideration. The first stages of a water flood require the most water because the reservoir pore space not filled with liquid must be filled with flood water. This is without a great deal of produced water from the producing wells. To obtain a maximum oil production as rapidly as possible it is necessary to reach the "fill-up" period as soon as possible.

As stated by Wilson, Brown, and Sheppard[23] the total volume of water needed to flood a reservoir to depletion ranges between 0.5 and 1.5 pore volumes. Many factors seem to influence this value of total water, but it has been suggested that the type of reservoir, the degree of control of the flood, and the amount of by-passing of the flood are most important.

The rate of water required for a flood is often estimated between 1 and 50 bbl per day per ft of sand flooded. Recycling of produced water may reduce this overall volume of water required, but recycling requires additional gathering and treating facilities and may not be economically feasible.

Water supply volume requirements will depend on whether the produced water is recycled. H. S. Barger[5] has suggested that with recycled produced water the volume of water supply required should approximate the volume of fluids produced to date plus the volume of waterflood oil expected. Consideration should also be allowed for water which will be lost to thief zones, to the outside extremities of the reservoir, to unplugged holes that may permit water to migrate into other formations and gas zones. Total volume of water supply on an average, when the produced water is recycled, will approximate 1½ to 2 times the natural and waterflood oil produced. When the produced water is not recycled, the total volume of water supply will approximate 15 times the waterflood oil recovery.

The daily requirements of water can be controlled by the rate of waterflood development and by the daily injection rate. The injection rates are suggested to be of the order of 0.3 to 1.5 bbl per acre-ft per day with 0.5 as a value economically satisfactory for most reservoirs. Barger[5] suggests that the rate for limestones is of the order of 2 to 3 times the average rate for sands.

The maximum daily requirements are needed for a period of one or two years, or until produced water reduces the requirements. The daily supply of water required late in the life of a flood using recycled water may be as low as 10 to 20 percent of the early daily injection rate. Any source of water should be investigated with respect to the long term prospect.

Type of Water — Fresh or Brine

Besides the volume requirements, the type of water should be considered. Both fresh water and brines have been used for waterflooding. Salt water is usually preferred to fresh water for flooding. This is due to the reaction of fresh water with the clays in the formation and the resulting clay swelling and formation plugging. The quality of brine waters is often uniform, but the brine may require treatment for corrosion and plugging.

The choice between fresh water and brine is often related to the area. In the Rocky Mountains fresh water is available and good sources of brine may be hard to find. In other waterflooding areas the opposite is true. All over the Southwest and Midwest fresh water is in short supply. Not long ago a flood in Oklahoma was shut down for lack of water due to the drought.[6] In the fu-

ture it is expected that the state authorities will protect and conserve fresh water supplies. Even where fresh water is available, however, many operators in this area are choosing the use of brine for flooding.

Quality of the Water Supply

A major factor in selection is the quality of the water supply. The supply water should be chemically compatible with the connate water or be easily made compatible by chemical treatment. A complete chemical analysis of both supply and connate water is desirable for study. All chemical reactions between constituents should be evaluated. Visual observation of reactions in the mixed water should be performed.

The supply water should also be considered in the light of any clays or shales in the formation which may be altered. Corrosion constituents should be held to a minimum, removed, or made ineffective. Of course all water supply must have a relatively stable chemical composition so that treatment may be effective.

Another problem in supply water is the presence of suspended matter which may cause plugging.

Also, waste waters and improperly plugged wells often contaminate a source of water, and this should be investigated.

The general considerations governing the conditioning of water for subsurface injection are much the same whether the purpose of injection is waterflooding, reservoir-pressure maintenance, or brine disposal. The principal object is to reduce corrosion and prevent plugging of the formation.

Location of the Water Supply

In selecting the source of water for waterflooding it is apparent that quantity, type, and quality are major factors. Location of the source of water is the fourth component to be examined.

Surface water may be obtained from streams, rivers, lakes, or ponds.[12] Surface sources usually require pumping from a stream, dams, with or without intake boxes or settling basins to prevent plugging the lines. The chief disadvantage of such source is the suspended materials in the water. The mud, sand, clay, and organic materials must be removed. Another disadvantage is the changing quality of the water, for this requires continuous supervision for treatment.

Springs are another surface source but quantity is often the chief problem. The use of springs as a water source eliminates the necessity for supply pumps and other underground equipment. The quality is generally better and mechanical impurities are usually less than in other surface water sources.

Subsurface water supplies are the chief source of water for waterflooding. Subsurface sources may be produced from free ground water or from a confined strata between two impervious layers. Water wells produce from both sandstone and limestone formations. This water supply is fairly constant in quantity and quality. The shallowest water supply is not always the most economically favorable. An assured deep source is preferred to a shallow formation of varying ability to produce. Water supply wells are usually produced by either turbine or rod pumps or by gas lift. Pumps and water supplies may fail, but water floods, once started, should not be interrupted for this interruption may cause loss of oil production.

Gravel beds are sources in many areas. Wells drilled into the gravel usually produce more than wells in consolidated formations. Quality may often be seasonal and surface contamination is possible.

A municipal water supply is sometimes used as a source of water for injection. It is even possible to form a private company to supply water for the flood.

Also, there are several recent floods[17] using treated sewage effluent as a flooding medium.

TABLE 1. Summary of Source of Injection Water for Flooding in the Mid-Continent Area.

Kind of Water Injected				
Surface and produced brine	Surface only	Surface, subsurface and produced brine	Subsurface only	Subsurface and produced brine
6	1	1	4	14

Source of Water						
Surface			Subsurface			
River	Lake	Municipal	Arbuckle	Mississippi	Douglas	Other
5	1	1	15	1	1	2

Source of data: Bureau of Mines, Report of Investigations 4930.

APPLICATIONS

With a general survey of water sources for waterflooding in mind, emphasis may be to applications for specific areas. The tables presented are a summary of the data on water sources as published and available to the author. They are only typical groups and do not represent all the floods in any one state.

Mid-Continent (General)

Secondary recovery projects in the Mid-Continent area[23] obtain the flooding water from both shallow and deep wells, from surface water such as lakes, rivers, springs, and in some instances from municipal water plants and sewage disposal plants. Produced brine is recycled in most of these water floods. The ratio of produced brine to source water is often as high as 10 to 1.

In northeastern Oklahoma and eastern Kansas water from the Arbuckle group is used extensively for waterflooding. This water source is usually by means of wells completed in this formation. This water supply varies greatly in different localities, however. This formation produces fresh water pure enough to be used for a city water supply in one area while in another location the water is found to have high solids and chloride content. Dissolved gases such as carbon dioxide and hydrogen sulfide are usually present in large amounts. Waters from the Mississippi limestone and Douglas sandstone are also used for flooding in the Mid-Continent area.

In some fields the cheapest and sometimes the only supply is a lake, river, or surface reservoir. Surface waters have low salinities, low total mineral content and low dissolved gas content, except for dissolved free oxygen. Surface waters show a seasonal variation especially with regard to suspended matter. In spite of this seasonal variation and its tendency to reduce permeability by clay swelling the fresh water source is used extensively in the Mid-Continent area.

Shallow water wells produce water somewhat similar in chemical composition to fresh water except this water usually has greater hardness, higher alkalinity and lower free oxygen content.

Some operators buy flood water from municipal water supplies or from sewage disposal plants. This source of water is usually more expensive than obtaining water from other sources. See Table 1 for a summary of source of injection water for flooding in the Mid-Continent area.

Oklahoma[1, 15, 19]

Most of the early water floods in Oklahoma were fresh water floods since this was similar to the practice at Bradford, Pennsylvania, where waterflooding was considered to have started. Also, the subsurface water in the Nowata field was found to be very cor-

rosive and not a good source. Since the Oklahoma surface supply of water is quite variable with the seasons, a subsurface water supply generally comes from the Mississippian lime or Arbuckle lime at depths about 300 to 1300 ft below the Bartlesville sand. Water treatment once determined for this water does not vary, but for surface supplies water treatment may require a great change over short periods of time.

At this time, over half of the flood projects in Oklahoma are using fresh water of which a large percentage is taken from rivers, streams, and ponds and the rest from wells with depths from 10 to 1200 ft.

The Arbuckle limestone is one of the most prolific salt water sources and varies from availability at a few hundred to more than 6000-ft depth. The Mississippi, Oswego, and Hunton limes, the Gilcrease, Calvin, Cromwell, and Dutcher sands are a few of the other formations which are used as salt water sources.

Produced water is utilized by mixing with fresh and salt injection water. Some mixtures require only a minimum of treatment while others require extensive systems.

Let us now consider the source of water obtained for a specific flood, that of the Canary field.[4] This field is located in Washington County in Northeastern Oklahoma.

Injection water was initially obtained from the Roubidoux formation from a well equipped with a high fluid capacity submersible electric multistage centrifugal pump. As water production from the Bartlesville formation flood increased it was proposed to mix the Roubidoux and Bartlesville water. This was found to produce precipitates that could cause plugging so the plan was rejected.

Arbuckle limestone water was found to be saturated with H_2S. A treatment and a closed system produced a compatible mixture of source water and produced water but the treatment proved very costly. Finally a system was devised in which Arbuckle water made up of brine and H_2S gas was passed through a separator and the liquid from the separator was transferred to the suction of the injection pump for the water flood. See Table 2 for source of injection water for flooding oil sands in Oklahoma.

TABLE 2. Summary of Source of Injection Water for Flooding Oil Sands in Oklahoma.

Source of Water	Number of Projects	Kind of Water	
		Fresh	Brine
Shallow fresh-water sands	24	24	—
Rivers, creeks, and ponds	80	80	—
Municipal water systems	7	7	—
Arbuckle formation	17	—	17
Shallow brine aquifers	12	—	12
Brine from formation flooded	13	—	13
Brine from other oil-bearing formations	7	—	7
Total	160	111	49

Kansas[13, 18, 28]

In Kansas the principal sources of salt water are the Mississippi and Arbuckle limestones, Douglas sand and return salt water. The flood projects that employ fresh water obtain it chiefly from rivers and gravel wells.

Mississippi and Arbuckle brines are sour and must be aerated in most cases. Many attempts have been made to inject sour brines through a closed system but plugging and corrosion have made costs prohibitive. There are examples in Kansas and there are floods in Oklahoma where Arbuckle water has been found to be low enough in sulfides to be injected through a closed system without treatment. Douglas sand brine with a closed system has been successful in several floods. Corrosion problems have caused some troubles.

The equipment for supplying water for waterflooding varies with each operator. Gravel wells are many times pumped with small turbines. River sources utilize pumps mounted on floats which rise and fall with the river, or turbine pumps mounted on high platforms. Some deep water wells are pumped by conventional oil well pumping units while others use high fluid capacity submersible pumps or deep well turbines.

J. R. Lavens states that deep well turbines operate economically where a large supply of water is required and where the fluid level is not lower than 400 ft. The high fluid capacity submersible pumps are most practical where the fluid level is below 400 ft and large quantities of water are needed.

Air lifts and oil well pumping units have been found by most operators to be inefficient in this area and are not often used as permanent installations.

We will now consider the water source for a specific Kansas area, Greenwood County. The Tonganoxie sand in the Douglas group, commonly known as the "Big Water" sand occurs throughout most of Greenwood County, Kansas, at depths of 800 to 1200 ft. This formation is 100 ft thick and contains salt water. Many waterflood projects in this area have used the Douglas water for flooding. Due to thickness changes and depletion, however, subsurface water from the Arbuckle zone and surface water are being mixed and used on new projects.

One specific flood in this area was started on water supplied from the Douglas sand. This water supply was augmented by water taken directly from the Verdigris river. A similar flood in the area started on water from the Douglas sand and after this was inadequate an Arbuckle water supply well was placed in operation. There are numerous examples of the use of produced water mixed with the Arbuckle water with the mixture then being appropriately treated to prevent plugging.

See Table 3, for a summary of source of injection water for flooding in Greenwood County, Kansas.

As has been stated previously, an adequate, reliable supply of a suitable water is one of the major requirements for a successful water flood. Waterflooding has been in practice in the oil fields of Anderson, Franklin, Linn, and Miami counties, Kansas. The first few waterflooding projects in this specific Kansas area utilized fresh water from streams or ponds. Because of the restriction of these surface sources of supply during dry seasons, wells were drilled for some floods to obtain brine from deep formations when other supplies failed. After the advantages of brine became better known and the availability of a reliable supply from the Mississippi and Arbuckle limestone was established, many floods were begun with these water sources as the principal source of supply. At the present time more than 50 percent of the waterflooding projects in this Kansas area depend chiefly upon brine wells.

TABLE 3. Summary of Source of Injection Water for Flooding in Greenwood County, Kansas.

Total Projects	Kind of Water Injected		
	Brine	Fresh Water	Mixed
44	39	2	3
Total Projects	**Source of Water**		
	Surface	Subsurface	Mixed
44	2	38	4

TABLE 4. Summary of Source of Injection Water for Flooding in Kentucky.

Total Projects	Kind of Water Injected: Brine	Fresh Water	Mixed
10	4	6	0

Total Projects	Source of Water: Surface	Subsurface	Produced	Mixed
10	3	6	1	1

Kentucky[21]

For most of the water floods in the area of Illinois, Indiana, Kentucky, Ohio, Michigan, and West Virginia, a good local water supply is available. West Kentucky is unusual in that most of the water sands are lenticular and of small area. Rivers offer a source of water but this increases costs for the flood because of the larger expenditures for lines, pumps, and plants.

See Table 4 for a summary of source of injection water for flooding in Kentucky.

Illinois[17, 18, 21, 26]

In Illinois, Southeastern field first started waterflooding in 1924 with fresh water from surface sources. In many areas of Illinois fresh water may be obtained from shallow wells in glacial drift. Produced salt water or salt water from upper water-bearing sands have also been used for injection purposes.

In the Siggins area flooding was started by water from drift wells located 5½ miles from the oil reservoir. Later the water injected into the reservoir was a combination of fresh and produced salt water at about a ½ and ½ mixture.

In the Patoka field, Tar Springs salt water is produced to the surface from the 1000-ft sand and injected into the lower Bethel sand. Water is produced from the Cypress by perforating opposite the upper water-bearing strata and allowing the water to flow by gravity to the McClosky pay zone. This type of flood precludes complete data from being obtained on volumes of water injected, although "down the hole" water meters have been occasionally used in this area.

The Mattoon water flood, located in Illinois, includes 28 injection and 32 producing wells. A pilot flood with brine proved the success of the flood but expansion required another source of compatible water. The effluent from the municipal sewage disposal system was treated and some 2½ million bbl have been injected to date. No permanent plugging has been noticed although detergent soaps require periodic acid treatments of the injection well bore.

See Table 5 for a summary of source of injection water for flooding in Illinois.

Indiana[21]

See Table 6 for a summary of source of injection water for flooding in Indiana.

Michigan[3, 21]

In general, in Michigan fresh water is injected into the oil producing zones. The produced salt water is returned to the oil producing zone by separate salt water disposal wells. The fresh water and salt water are never mixed at the surface. Fresh and salt water injection wells are combined in each pool, however, to give a line-drive waterflood pattern.

Fresh water is from sands approximately 300 ft deep and is treated before reinjection. The salt water returned to the producing formation is not treated.

New York and Pennsylvania[22, 24]

In both New York state and Pennsylvania, fresh water rock and gravel formations are the chief source of water for flooding purposes. Surface water is a last resort due to excessive dissolved oxygen, silt, and minerals. Very few plants are using salt water.

Ohio[7, 21]

Most operators in Ohio are using a mixture of brine recycled from producing wells and fresh water from wells in alluvial deposits 160 ft deep or fresh water from nearby rivers. Chemical treatment is necessary before the water is injected into the formation.

See Table 7 for a summary of source of injection water for flooding in Ohio.

West Virginia[11, 21]

In West Virginia flood water is obtained from small mountain streams and the produced water is not returned to the formation.

Arkansas

Waterflood operations in Arkansas

TABLE 5. Summary of Source of Injection Water for Flooding in Illinois.

Total Projects	Kind of Water Injected: Brine	Fresh Water	Mixed
72	43	21	8

Total Projects	Source of Water: Surface	Subsurface	Produced	Mixed
72	2	48	7	15

TABLE 6. Summary of Source of Injection Water for Flooding in Indiana.

Total Projects	Kind of Water Injected: Brine	Fresh Water
7	5	2

Total Projects	Source of Water: Subsurface	Produced	Surface
7	2	3	2

TABLE 7. Summary of Source of Injection Water for Flooding in Ohio.

Total Projects	Kind of Water Injected: Brine	Fresh Water	Mixed
4	0	4	0

Total Projects	Source of Water: Surface	Subsurface	Produced	Mixed
4	3	1	0	0

TABLE 8. Summary of Source of Injection Water for Flooding in Texas.

Total Projects	Kind of Water Injected: Brine	Fresh Water	Mixed	Unknown
89	58	15	6	10

Total Projects	Source of Water: Surface	Subsurface	Mixed	Produced
89	3	46	25	15

consist of repressuring or salt water disposal operations.

Texas[9]

The water used for flooding varies from hard surface to corrosive brines.

See Table 8 for a summary of source of injection water for flooding in Texas.

California[10, 14]

Sea water for waterflooding is about 17 percent of the injection into the California oil fields. One operator has drilled four water source wells approximately 75 ft from the ocean. The first water source well was completed with 16 ft of 40-mesh perforations. In about 20 months and after 1,500,000 bbl of total water produced the well was abandoned because of the flow of gravel into the well.

Other supply wells were drilled and completed to prevent the known corrosion. The produced water consists of the same composition as the ocean water except for the reduced free oxygen content. Corrosion is a real problem in both the water source well and the injection well. Pipelines, tubing and casing have been plastic coated as a corrosion control method. Stainless steel is used in the source well pumps and inhibitors are being used to protect the injection well.

Another California operator is obtaining sea water from an excavated pit in the tidal area of the beach. Glass reinforced plastic pipe is used in the intake system. Corrosion here is reduced by treatment and by use of bronze, porcelain, and nylon parts in the pump. Corrosion treatment consists of reducing the free oxygen content to less than 0.3 parts per million.

In California, of 15 total projects, brine was used for injection in all 15 waterflood operations.

SUMMARY

To summarize some of the more important considerations:

First, in selecting a source of water a satisfactory quantity of water is of major consideration.

Second, supply water should be of compatible quality.

Third, the number of water floods using brine appears to be increasing while the number of fresh water floods is decreasing.

Fourth, in practical application there are numerous combinations of water source and type possible.

Finally, it is estimated that water requirements in oil production will double within the next decade. With increasing emphasis on waterflooding the problem of proper water source selection increases in importance. A comprehensive study of the advantages and possibilities of various combinations and a search for new water sources should be investigated.

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Gulf Opens Two Drilling Research Units

Two new buildings, designed specifically for research to reduce drilling costs and increase the amount of petroleum recovered from oil fields beyond the present average of about 50 percent, were opened recently at Gulf Oil Corporation's Harmarville, Pennsylvania, Research Center.

The structures will be used in an intensive program of production research.

Gulf's staff will tackle the specific assignments of improving the speed and economy of drilling wells, and achieving greater oil production by such techniques as warming the reservoir by burning a small part of the oil underground (in-situ combustion) or cracking the rock formation (fracturing) hydraulically.

Of the two structures, the smaller "Drilling Building" is the more unusual. Of concrete block and translucent plastic siding, 61 by 56 ft, it is erected around an 80 ft oil derrick. The derrick platform stands 13 ft from the floor within the building; and its superstructure extends through the roof. Hinged roof panels permit opening the roof during derrick operations.

The major structure, named the W. L. Mellon Production Research Laboratory, is four stories, steel frame and brick, 227 by 53 ft. It houses 94 laboratory work rooms and offices. This building is completely air conditioned, fluorescent-lighted and plaster-walled. An underground passage connects it with other structures in the Center.

The Drilling Building is planned to duplicate field operations with heavy equipment. Large blocks of rock will be used for drilling studies, with experimental methods, chemicals and mechanisms, in which actual conditions will be reproduced down to the use of a mud pit.

The building was designed, in part, to eliminate many of the "bugs" in experimental techniques and drilling tools before field testing. This means research developments will be further advanced than in the past when introduced to the field. More speed and efficiency in transferring results into practice will be gained.

The main laboratory and office building, designed and constructed by Wigton-Abbott Corporation of Plainfield, New Jersey, will be shared by two divisions of Gulf Research and Development Company, with closely related aims, the Production Engineering division and the Reservoir Mechanics division.

nigerian oil safari

There's oil in Nigeria.

Shell-D'Arcy Petroleum Development Company of Nigeria, Ltd., is finding just how much and where. Five exploration wells and four appraisal wells have been drilled; others are underway. Three of the exploration wells encountered shows of oil — at Ibotio in Calabar Province, at Oloibiri, in Rivers Province, and at Afam, in Owerri Province.

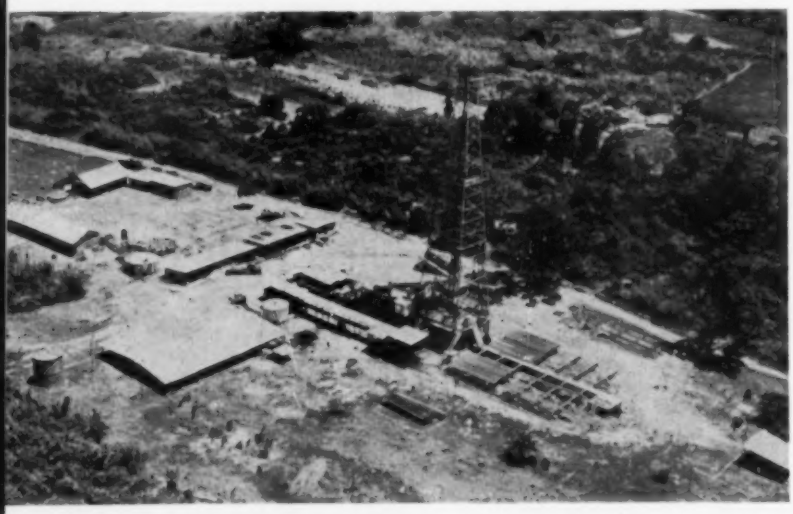
Although oil-bearing sand at Ibotio was disappointingly thin, encouraging results have been obtained at the Oloibiri well that drilled to 12,008 ft. This well encountered three thin sands between 8000 and 9500 ft. Latest oil find was at Afam, 20 miles east of Port Harcourt, in Owerri Province.

Two additional wells have been drilled at Oloibiri and completed successfully. Transportation and communication facilities, however, are not such as to warrant construction of production and transmission facilities, say company officials. Further development is to continue, and plans have been announced for construction of a 10-in. pipeline from Oloibiri to Port Harcourt for an extended production testing phase.

At Afam, an appraisal well is now being drilled. A second exploration is drilling at Akukwa, where high pressure gas was encountered in 1955, in order to determine if any oil is associated with the gas. A second exploration well drilled at Ituk, Calabar Province, has been suspended, pending arrival of fishing tools.

Three drilling strings and four seismic survey parties were in operation at the end of 1956, drilling a total of 60,000 ft last year.

* * *



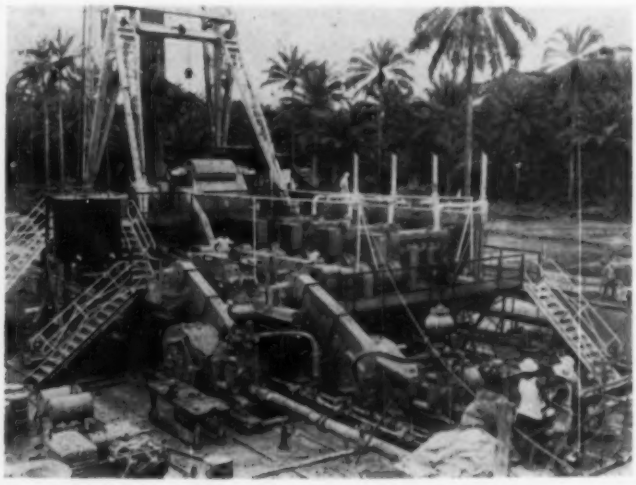
70 miles north into nowhere in the African jungle is this Shell-D'Arcy Petroleum Development Company rig. Rig is on location at Nzam, 70 miles north of Owerri, Nigeria. The firm, jointly owned by a Shell company and British Petroleum Company, is working an area of 58,000 sq miles in Nigeria.

Largest Shell-D'Arcy rig, drilling here at Nzam, failed to find oil. Showings of oil have been found at Akata and Ituk Mbang in Calabar Province, and at Afam.

Roughnecks are where you find them — these on the floor of a 10,000 ft rig at Akata, Nigeria. Much of the work being done by Shell-D'Arcy is carried out by British and American trained oilmen.

Truck mounted portable rig at Calabar, in eastern Nigeria, is the smallest of three being used to explore oil possibilities on Shell-D'Arcy's huge concession. Oil bearing sand in the Calabar area has been disappointingly thin.

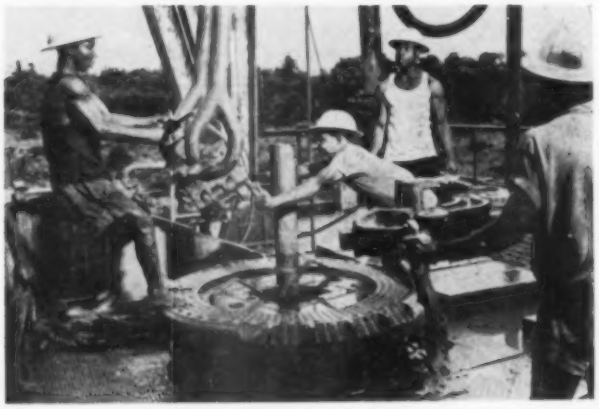
10,000 ft rig at Akata, in Calabar Province, where appraisal wells are being drilled following discovery of oil and gas shows in deep drilling tests in 1953.



Successful Shell-D'Arcy drilling prompts pipeline construction, exploration, expansion

Chief of a local family signs an agreement for the lease of land to Shell-D'Arcy required for industrial purposes. This scene was in the schoolroom at Isaba near Port Harcourt.

Paleontological laboratory at Owerri pieces together the fragments of information about the geology of Nigeria. In developing this concession, Shell-D'Arcy has preceded actual drilling with extensive aerial surveys, geological, seismic, gravimetric and core drilling exploration.



With oil comes progress. The Enugu Trade Center provides the most modern training in several trades, including motor mechanics, sheet metal working, carpentering, blacksmithing, welding, etc. Students from this center have found employment in Shell-D'Arcy's exploration program.

Drilling supplies are ferried by this LCM at the water transport point of the River Niger at Onitsha. Base camp for operations is at Owerri and a transport of over 50 vessels used principally in the Niger Delta area is centered at Warri 90 miles further west. Some helicopters are being used to shorten communications lines.

In the laboratory and in the field, Gulf Oil Corporation's . . .

New PERCUSSION DRILL

A new type percussion drilling tool, developed and patented by Gulf Oil Corporation and soon to be licensed for commercial use, was unveiled recently at Gulf's Research Center at Pittsburgh, Pennsylvania. Tested in the laboratory and in the field, the new "hammer drill" is expected to drastically increase rates of penetration in dense rock and will help solve the crooked hole problem. Full-scale runs at Gulf's Research Center under the supervision of E. Topanelian Jr., director of Production Engineering for Gulf Research and Development Company, indicate that it may be one of the major drilling developments of recent years.

The tool is expected to provide savings in money, time and maintenance as a result of faster penetration, up to 50 percent, and increased bit life, which in tests to date show up to 300 percent

Here's How It Works

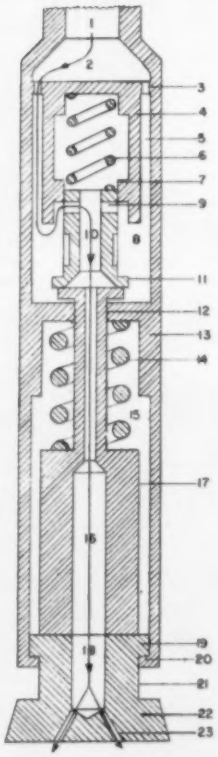


FIG. 1. **Hanging position,** tool is open and is being lowered to bottom. Fluid is bypassed through passages 9, 10, 16, and 18 so that circulation can be established while reaming to bottom.

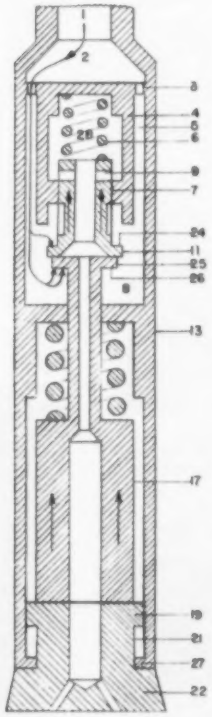


FIG. 2. **Starting position.** Tool is set on bottom to collapse anvil 21 which has a hexagonal slip joint. Fluid is now trapped in chamber 8, and clamps valve and hammer lips together.

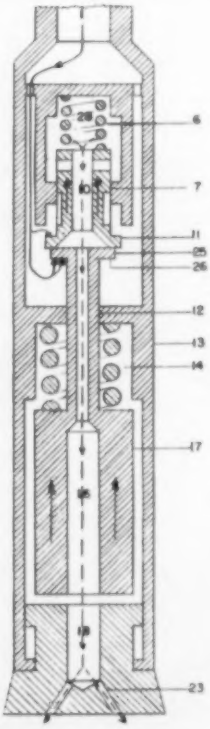


FIG. 3. **Hammer and valve** moving up under fluid pressure due to net diameter of valve piston 7 being greater than diameter of hammer stem 12. Resultant pressure acts upward on net area.

Shows Great Promise

Nearing commercial stage, new "hammer drill" is expected to cut drilling costs, help solve crooked hole problems

longer than in conventional rotary drilling.

The "hammer drill" was originally designed to punch through hard friable (or brittle) rock such as the chert overlying the rich Ellenberger pay in West Texas. Recent tests indicate it should be equally effective in other tough formations such as occur in the Mid-Continent and Rocky Mountain areas and Canada.

Description of drill. The tool consists of a reciprocating piston and cylinder arrangement for delivering percussion blows. It is powered by the drilling mud which must be kept circulating through the hole to remove the cuttings. This gives it the additional name of "mud engine."

The device is encased in a cylinder approximately 19 ft long which hangs at the end of the drill string, with a conventional rock bit fastened directly below. As the drilling mud circulates through the mechanism, it drives a 200-lb hammer delivering 600 or more strokes per minute on the attached bit.

How it operates. Meanwhile the drill is slowly rotated under a load which may vary from 6000 up to 40,000 lb, depending on down-hole conditions. The bit teeth are thus successively positioned and driven against the hole bot-

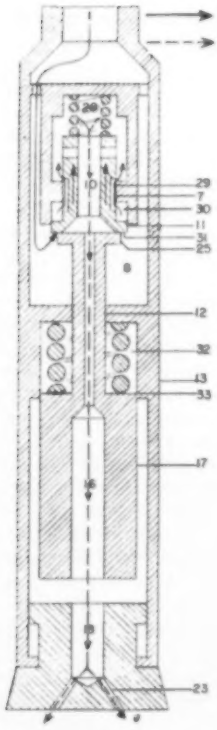


FIG. 4. **Hammer reversing.** Pressure above valve lip is relieved through communication of port 29 with low pressure chamber 28. Area 31 is now at higher pressure than area 24 and valve accelerates, hammer drops.

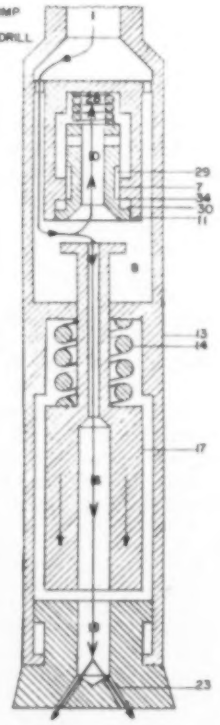


FIG. 5. **Valve reversing.** Hammer dropping and valve about to drop. A conventional tungsten carbine tricone bit is attached to the anvil in full-scale laboratory and field tests.

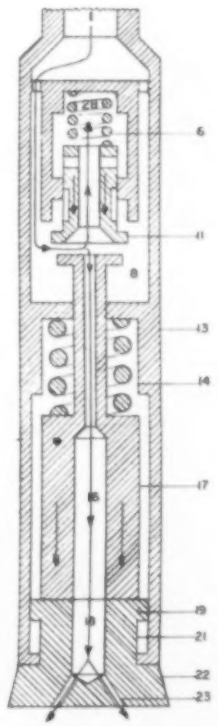
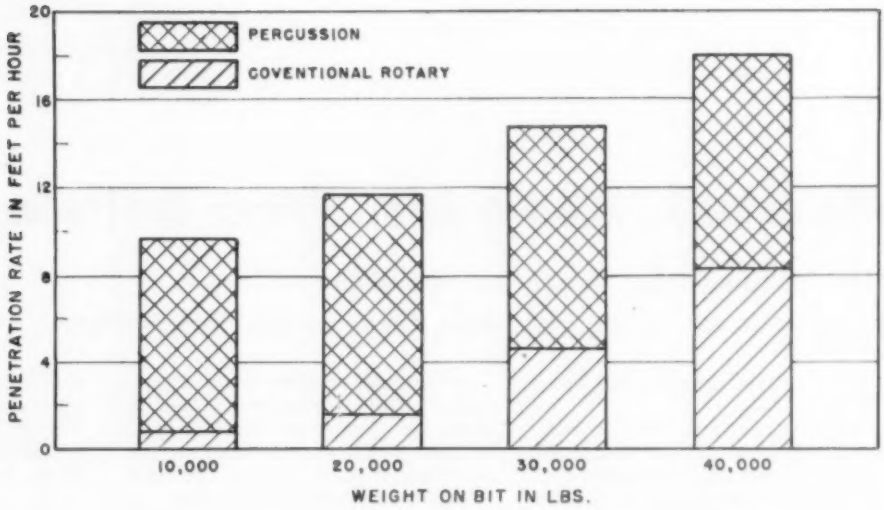
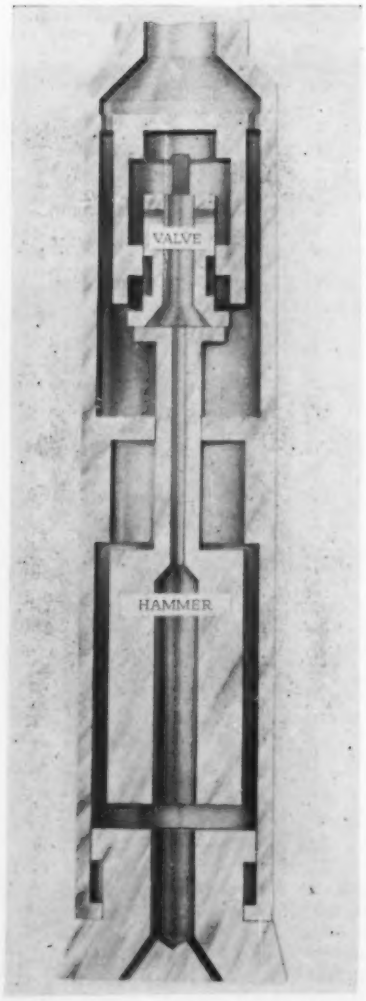


FIG. 6. **Hammer striking anvil.** Hammer is driven down by gravity, hammer spring 14 and pressure drop of fluid through small passage above chamber 16. Fluid passes through chamber 18 into bit.



Penetration rate vs weight on bit for conventional rotary and type "E" percussion bit. These are laboratory results from drilling in granite at 50 rpm with an 8¾-in. tungsten carbide tri-cone bit.



Gulf's percussion drill, type "E" shown in schematic cross section. Conventional rock bit is attached on bottom.

tom in a manner similar to that in which star drills are turned to make holes in masonry. Hanging almost like a plumb bob at the end of the string, the percussion hammer chops a vertical passage downward despite the hardness or the inclination of the formation.

By contrast, in conventional drilling the bit is attached directly to the end of the drill string, and is rotated against the bottom usually under heavy loads, averaging from 25,000 to 55,000 lb.

Field tests. These differences account for the "hammer drill's" faster penetration. In original field tests, where it drilled more than 6000 ft in 32 different holes in West and East Texas, Oklahoma, Nevada, and Canada, the new tool often achieved a rate of penetration (feet per hour) 25 to 50 percent faster than conventional rotary drilling.

Since then, on the basis of laboratory tests, it is estimated that an improved model will increase penetration through chert, dolomite, and hard limestone by two to four times over present rates.

Straighter drilling. And in hard slanting formations, the "hammer drill" is expected to maintain high penetration speed without excessive hole deviation sometimes encountered in conventional drilling. Reason for this is because, particularly when slanting layers of chert are encountered, the heavily weighted conventional drill string tends to drive the bit off at an angle. A similar effect can result when the bit progresses from one formation to another which is harder or softer.

To avoid crooked holes in such cases, the practice has been to lighten the string so it hangs vertical — which drastically reduces the penetration rate. Since the "hammer drill" advances by punching, rather than by boring under pressure, its vertical progress is not thrown off so badly by these conditions.

Low maintenance. Operationwise, field trials demonstrated the new tool could operate 60 hours without withdrawal for servicing. With recent improvements, 100 hours without withdrawal are anticipated. When taken from the hole, simple replacements can be made right on the rig, and the tool put back to work.

Bit wear. Since runs are much longer than bits can be kept in the hole, the "mud engine" outlasts three or four bits before servicing.

When running with light loads, percussion drilling does not wear down bits so rapidly, so that bit life is increased in some cases by 50 to 300 percent. In one area where conventional methods made only 8 ft with a bit before it failed, the same type of bit drilled 27 ft when used with a "hammer drill."

Lesser bit wear will reduce the frequency with which the drill string must be pulled up, disjointed, reassembled and lowered again for bit replacement.

Further improvements. Engineers at Gulf Research and Development Company who designed and tested the tool believe that further improvements may be possible in the "hammer drill" as field use provides additional experience and extends the service periods for which bits may be used.

The new drill is fully covered by patents and ready for commercialization. Licensing negotiations are under way to make the tool available to the industry. ★ ★ ★

The Gravity Anomaly Simulator

'Structural Correction' for Gravity Maps

Low order anomalies may be revealed for the first time with the aid of a new electronic analog computer

Jonathan W. Phillips,
Gravity Interpretation Consultant, Neese Exploration Company
Houston, Texas

A structural interpretation of gravity data is now possible with the aid of a new electronic analog computer developed specifically for quantitative gravity analysis. Previous to this development gravity analysis has been limited mostly to qualitative studies wherein only the location of an anomalous area is of interest. The machine permits application of a new technique termed *structural correction* to existing gravity maps. By computing the isolated effect of known structures and subtracting these from the observed gravity, low order anomalies may be revealed for the first time.

Lying dormant in the files of most major oil companies and a few independent operators are many gravity maps of unknown value. Cost of obtaining these maps may be quoted as millions of dollars but their value as undeveloped data may be even more. Application of this new technique for analyzing these maps may reveal a new wealth of information.

A new analog computer called a "gravity anomaly simulator" utilizes light flux as an analog of gravitational flux to compute these structural corrections. This permits computations to be made in a few days that would have taken months by older methods.

Gravity Anomaly

Object of all this interest is the gravity anomaly. Webster defines an anomaly as a deviation from the norm. The gravity anomaly is a deviation from a smooth and regular potential field which should be produced by the earth at its surface if there were no mass irregularities in its crust. There are, of course, many such irregularities due to mass displacement within the basement rocks and sedimentary section of the crust. The sedimentary section, being much shallower, causes much sharper deviations of the gravitational field over local geologic structures. These deviations are termed local anomalies.

Corrections

Primary objective of gravity analysis is the isolation of local anomalies in the potential field and interpretation of these anomalies in terms of geological structure. Before data observed in the field can be used, it must undergo a series of corrections to eliminate the distorting effects of physical influences other than those due to the structures being sought.

One of these influences is the elevation of the gravity station itself. Two factors are involved in the elevation effect. One is the distance of the station from the center of the earth. A gravity meter can detect differences in this distance on the order of one foot. Due to this sensitivity, all the stations are corrected to a datum plane, usually taken as sea level. The other factor is the result of discrepancies in material between the datum plane and the observation plane of each station. The elevation correction eliminates the influence of both of these factors.

Latitude correction removes the effect of the oblateness of the earth and the centrifugal effect of its rotation. The drift correction accounts for the mechanical characteristics of the meter itself and tidal effects of the sun and moon.

Gravity Maps

After all these corrections have been applied, an isogal map may be constructed by spotting the stations accurately on the datum plane and contouring the points of equal field strength. This map is technically known as a Bouguer anomaly map but is sometimes referred to as a "raw" gravity map.

The map may be "cooked" by removing other distorting influences which serve to obscure and obliterate any anomalies due to sedimentary structure. One of these distortions is the broad, low ordered, regional gradient of the isogal contours due to igneous basement rock configuration and regional lithologic changes. This effect may be removed by one of several methods, some of them satisfactory.

In an area of harsh topography, it is desirable to remove distortions due to terrain. This is done by computing the excess of mass above the observation plane due to mountains and hills and the deficiency of mass below due to valleys and depressions in the area of interest and subtracting the combined effect at each observation station.

Ideally the resultant map, after these corrections have been applied, should show only those effects due to sedimentary structure of commercial interest in petroleum exploration. If there were no such structures the map would be a total blank without a single contour line evident, since every point on the plane would have the same gravitational potential as every other point. This, of course, is not the case. There are many evident anomalies on the map and

many of them are caused by known producing or non-producing structures. Some of the anomalies are only errors of faulty regional removal but where the basement is deep these can be eliminated or suppressed by the competent geophysicist.

Resolving Power

The factor that makes the gravity map difficult to interpret is what is known to the physicist as the poor resolving power of potential field methods. By resolving power, we mean the ability to distinguish between one object and a group of objects when they are in close proximity. If you are nearsighted, your eye is at the limit of its resolving power when it is unable to separate into two distinct sources the headlights on a distant car at night or to distinguish the individual leaves in a tree.

Potential fields are even more myopic and a simple experiment will prove it. Place two simple bar magnets close together but not touching, on a flat surface and put a sheet of paper over them. Now sprinkle some fine iron filings evenly over the paper. The filings will quickly align themselves in the potential field caused by the magnets and will outline each individual magnet so that its shape can easily be detected. Now brush the filings clear and try the same experiment with the paper raised a half inch over the magnets. The magnets are not so clearly outlined as before and if the experiment were repeated, each time raising the paper a fraction of an inch, a point would be reached where the fields of the magnets appear to merge and the fact that more than one magnetized body were the causative source would be impossible to determine by studying the potential field as outlined by the filings. This is the limit of the resolving power of the potential field of the magnets.

Now repeat the experiment with the paper at a half inch so that the position of each magnet is just barely detectable. Brush the filings clear, raise one of the magnets so that it touches the paper and sprinkle on some more filings. Since the shallowest magnet has the strongest field, the filings will outline its shape so clearly that the position and shape of the other magnet is completely hidden. The potential field of the deeper magnet still affects the filings even though the effect is distorted and if the distorting magnet is removed the remaining magnet may again be detected.

This phenomenon is brought to your attention because it is analogous to situations that exist in the study of gravity potential fields in the search for petroleum.

Anomaly Resolution

The gravity anomaly due to a structure covers an areal extent several times that of the structure itself. In an area where the structures are closely grouped it is sometimes impossible to resolve their overlapping effects into the separate anomalies by standard procedures. Sometimes a resolution can be obtained by application of second derivative methods but it must be remembered that the second derivative of a potential surface is proportional to the curvature of that surface. Where the overlapping is so great that no curvature reversal exists or where the station spacing is too loose to define the reversal, the resolution is impossible.

When anomaly resolution is unobtainable by any other method and sufficient subsurface data is available it is possible to resolve overlapping anomalies by removing the effects of the known structures. This procedure is analogous to the terrain correction and, in fact, may be termed a structural correction. In this fashion the distorting effect of known structure is removed to reveal the obscured and sometimes unsuspected effects of unknown and prospective structures. From this resolution

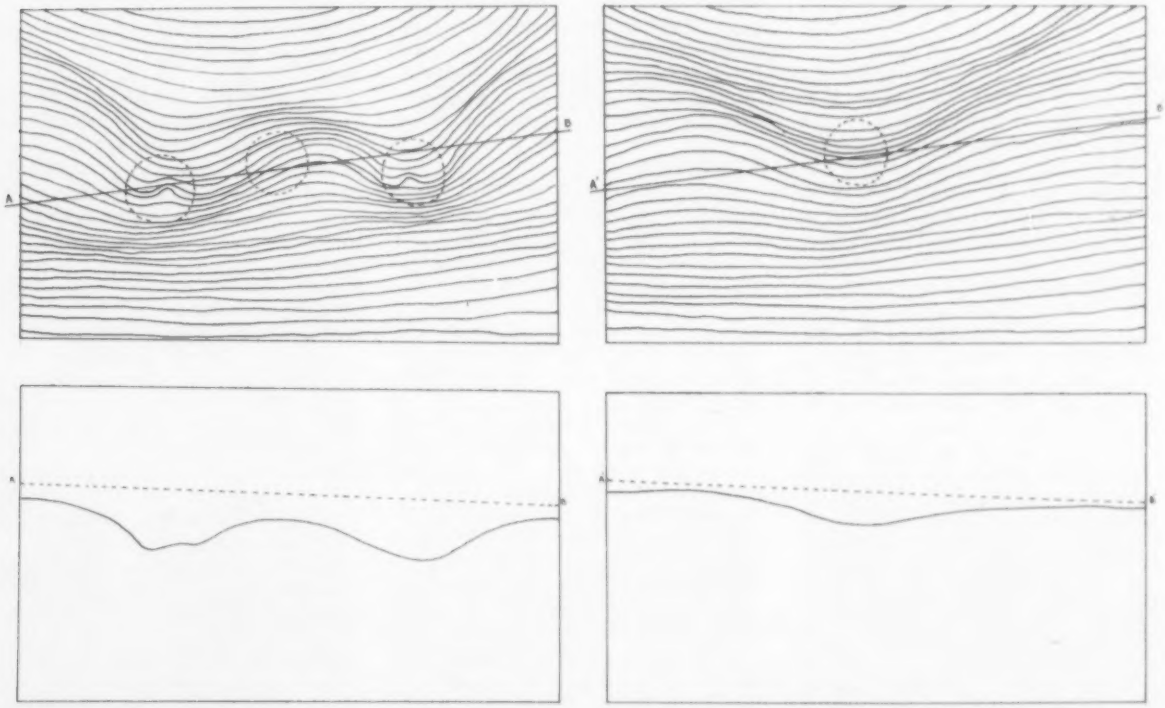


FIG. 1a. **Bouguer map** of an area shows the gravity effect of two shallow piercement domes on either side of a deep salt dome. Dashed lines indicate the structural extent of each dome. Although the effect of the dome is present, it is distorted and obscured by the stronger fields of the shallower domes. The profile AB of the potential surface is shown below.

FIG. 1b. **Same area** as shown in Fig. 1a with the effects of the shallow domes removed. Quantitative analysis of the residual field will approximate the structural boundaries of the salt mass.

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a computation of the extent and configuration of these unknown structures may sometimes be made. This method has been used quite effectively on salt domes of the Gulf Coast where shallow piercement dome effects have obscured the broad effects of hitherto unsuspected deep domes and residual salt anticlines.

Methods of Computation

Before the gravity effects of known structure can be removed they must be computed and it is necessary at this time to investigate the different methods of computation.

In computing the vertical gravitational component distribution on a horizontal plane over a buried mass, one must assume the body to have a density equal to the difference in density, σ, between that body and the material in which it is buried. The vertical component at the origin of a Cartesian coordinate system may be expressed

$$G_z = \gamma \sigma \iiint \frac{z \, dx \, dy \, dz}{(x^2 + y^2 + z^2)^{3/2}} \quad (1)$$

where γ is the gravitational constant, x, y, and z are the coordinates of the centers of the infinitesimal volumes, and the integral is taken throughout the volume of the body. This is a rather difficult formula to apply to any but simple geometrical bodies.

One may assume that the buried mass approximates in form bodies such as rectangular blocks, vertical and horizontal cylinders and spheres. The straight-forward analytical computation of Equation 1 for these shapes is fairly simple. One disadvantage of this method is that only one density contrast is permissible for the entire body. In cases where it is desirable to use a density contrast which varies with one or more of the dimensions we must resort to other means.

If we assume the limits on one of the horizontal dimensions of Equation 1 to be infinity in both directions,

$$G_z = 2\gamma\sigma \iint \frac{z}{x^2 + z^2} dx \, dz \quad . \quad . \quad (2)$$

It is possible to construct overlay templates and mechanical integrators to compute the integral of the remaining two dimensional cross section in the x, z plane. This technique is termed two dimensional analysis. Since the gravity meter measures only the vertical component of the gravitational field, a buried mass may be considered infinite in one dimension if its extent is 10 or more times its depth of burial. In two dimensional analysis, if the longest lateral dimension of the body is less than this minimum limit, corrections must be applied.

There is another method for computing the gravity effect of a horizontal slab of small vertical thickness and finite horizontal dimensions. If the thickness is kept small, Equation 1 becomes

$$G_z = \gamma \sigma \Delta z \iint \frac{z \, dx \, dy}{(x^2 + y^2 + z^2)^{3/2}}$$
$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (3)$$

where z is the depth of the central cross section.

That part of the equation under the double integral sign is exactly equal to the solid angle, ω, subtended at the origin by the cross section of the slab in the x, y plane at the depth z. If we let $\psi = \omega / 2\pi$ then

$$G_z = 12.77 \, \sigma \Delta z \, \psi$$
$$. \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad . \quad (4)$$

when linear dimensions are measured in units of kilofeet. Thus at any point the value of the vertical component of gravity due to a body of limited thickness and unlimited horizontal configuration is directly proportional to the solid angle subtended at the point by the central horizontal cross section of the body.

Since the computation is limited to slabs of small thickness any large mass must be divided into a vertical stack of irregularly shaped horizontal slabs. The shape of each slab is outlined by the contour of the mass at the depth of the center of the slab.

Analytically an irregularly shaped cross section may be approximated by a rectangle or a group of rectangles for which the solid angle computation is fairly simple although rather lengthy. Templates have been designed so that the solid angle is known for each zone of the template and the number of zones lying within the irregular cross section are simply counted manually. This is still a tedious method and a method of performing these computations electronically would remove a considerable time element as well as increase the accuracy of the results.

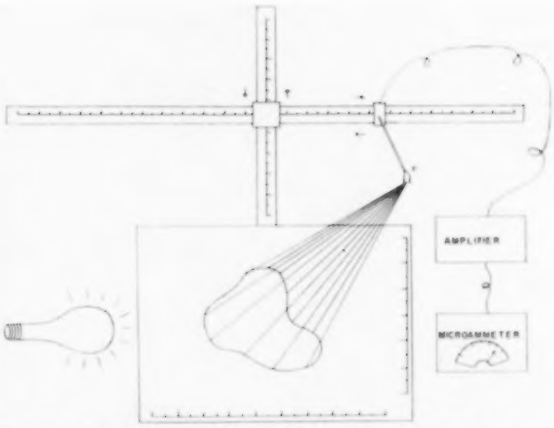

FIG. 2. **Block diagram** shows the essential working parts of the simulator. Solid angle of the irregular area outlined by the template is measured by the photocell, P, and its magnitude recorded by the milliammeter. The photocell is moved along the cross arm to measure the variation in profile.

Gravity Anomaly Simulator

The gravity anomaly simulator is essentially a solid angle measuring device. It consists of a light source mounted beneath a translucent screen that scatters the light as evenly as possible. Positioned over the screen is a photocell mounted so that it can move freely on a horizontal cross-arm. This, in turn, is mounted to move freely on a vertical rod so that the cell can be moved in two directions and its horizontal and vertical position measured by attached verniers. The current of the photocell, which is directly proportional to the intensity of the incident light, is amplified and measured by a microammeter.

In computing the effects of a buried mass such as a salt dome, a structure map of the body is contoured to the same scale which will be used on the machine. After calculating the required thicknesses of the slabs into which the structure will be divided, a template for each slab is made by cutting the con-

The Author

Jonathan W. Phillips received his BA degree in mathematics from the University of Arkansas in 1949. He did graduate work in physics at the University of New Mexico for a year and received an MS degree in geophysics in 1952 from the University of Tulsa.

In 1952, Phillips went to Opelousas, Louisiana, as field engineer with Schlumberger Well Surveying Corporation. He came to Houston, Texas, in 1954 as a geophysicist with Sohio Petroleum Company. He left Sohio in 1956 to serve as president of Exploration Techniques, Inc., until May 1957, when he was retained as a gravity interpretation consultant by Neese Exploration Company, Houston.

Phillips is an associate member of the Society of Exploration Geophysicists, a member of the American Geophysical Union and the American Association for the Advancement of Science.

tours of the center of the slab into opaque paper.

The solid angle of a simple plane geometrical shape such as a circle at a point over its center is easy to compute. If such a circle is cut into an opaque template and placed on the gravity anomaly simulator, the light intensity through its opening will be registered by a photocell at the origin by means of a milliammeter. Intensity of the source can be varied until the meter registers a convenient arbitrary value. The circular template is then replaced by a template cut to the desired irregular shape. Ratio of this meter reading to that of the circular template is equal to the ratio of their gravity effects at the origin if they are of the same thickness.

Gravity effect of the circular slab of known thickness, density, and solid angle is easily computed from Equation 3. Now we know the gravity effect, G_o, of an irregular slab at the origin. With the template in place we adjust the light intensity again until it reads a convenient arbitrary value M_o. In order to find the gravity effect at any point on the plane $Z = O$, we simply move the photocell about in this plane and record the observed meter readings, M_p. The gravity effect at any point P, is simply

$$G_p = M_p G_o / M_o \quad . \quad . \quad (5)$$

Locked-In Multiplier

The ratio G_o / M_o may be locked in as a multiplier in a desk calculator and as the readings are punched into the calculator the effect in milligals at each point is recorded. The time from the recording of one point to the recording of another averages about ten seconds.

Gravity effect of the entire body at any point is computed merely by summing the effects of all the slabs at that point.

With this computational aid to help us, it is possible to work backwards and reconstruct the mass configuration causing an observed effect. This is not quite as easy as computing an effect from an observed mass. Although there is only one possible effect for a given mass distribution, there are many possible mass distributions for a given effect.

As any mathematician knows, limits may be placed on an equation with an infinite number of roots so that only a few solutions are possible within these limits.

Unique Solution

It is interesting to note that if the shape of the mass is restricted to a sphere or a finite horizontal cylinder, and the density contrast is known, a unique solution for the dimensions of these bodies may be obtained from the magnitude of certain critical points on their associated potential fields.

In two dimensional analysis, if we confine the cross sections to simple geometrical shapes it is possible to compute the effects of such hypothetical bodies as infinite horizontal cylinders, and infinite rectangular blocks. If the density is known, a unique solution for an infinite cylinder may be computed from the magnitude of critical points in its potential field. This is also true for a rectangular block that extends to infinity in three of the four horizontal directions. This fact is very useful in fault studies when the gravity field stations are spaced closely enough to define the gradient changes.

You will note that in each case we have limited the shape and the density of the mass being sought. If limitations on shape are removed, computations must be done on a trial and error basis. Even under this handicap it is sometimes possible to reconstruct the shape and depth of burial of a deep dome whose effects have been revealed by the foregoing procedure. In some cases it is possible to determine the presence of

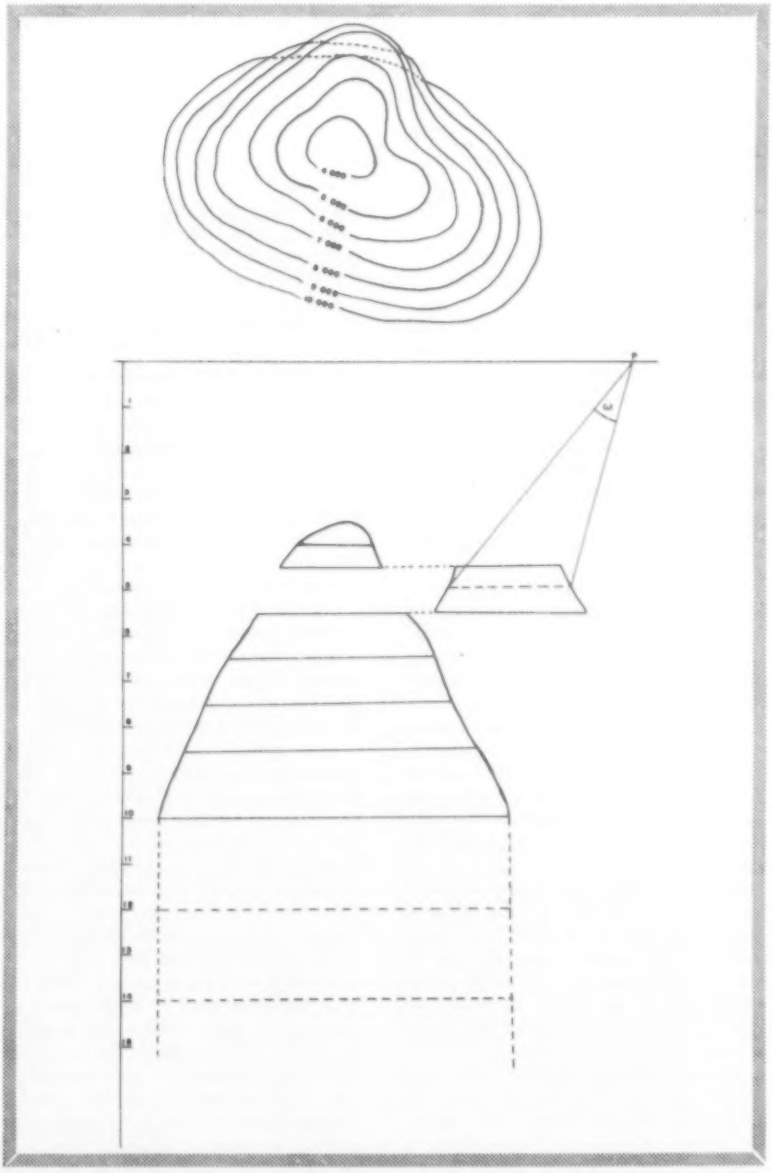

FIG. 3. **Contoured map** represents surface of a salt dome as it is known from well control. Below it is projected a cross section showing how the dome is theoretically cut into horizontal slices for measurement on the simulator. Depths are in kilofeet. The mean solid angle of each slab is determined and the cross section at that depth is cut into the template. Dashed lines below the depth of well control indicate how the shape of the dome might be interpolated initially.

FIG. 4. **Irregular cross section** may be divided into a group of rectangular blocks in this manner to determine its approximate solid angle analytically.

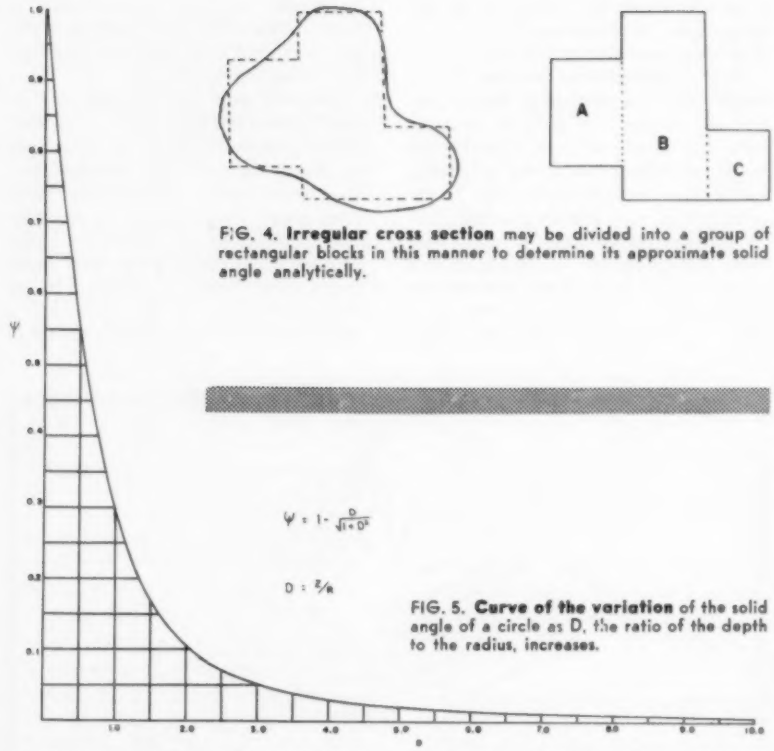

FIG. 5. **Curve of the variation** of the solid angle of a circle as D, the ratio of the depth to the radius, increases.

overhang on a dome and to place some limitations on the depth and amount of mass deficiency.

These applications are only the beginning of a new approach to quantitative gravity analysis that promises to unravel many problems in areas where other techniques have failed or are uncertain.

It should be remembered that no method of analysis is better than the data upon which it is based. It is for this reason that gravity maps of the future will exhibit the station control necessary for accurate analysis.

Station spacing today is based upon areal extent alone with no consideration for local or regional gradient. In order to define the true gravitational gradient it must be confirmed by several stations. On existing maps it is quite common to see the gradient between two milligal contours determined by only two stations. Frequently it is determined only by the pen and imagination of the contour artist. Because of this, present day gravity maps might be compared to seismic maps in the days of four trace records. The industry soon realized the value of additional traces even though they were not used in the actual computations. Even on multitrace records before the advent of modern plotters and computers, it was common practice to utilize the reflection times from only the first and last traces on a record to compute the dip of a horizon. The value of the remaining traces lay in confirming minor reflections which sometimes did not carry clear across the record. The value of close geophone spacing, so that statistical error is reduced and minor reflections confirmed, is clearly evident. Although it might be possible to analyze a two trace seismic record we would not have much conviction on picking the reflections. A one trace record is a nerve shattering conception.

The ideal gravity map for use in petroleum prospecting should have one station for each tenth milligal of change in the direction of maximum gradient and eight stations per mile in the direction of minimum gradient.

For mineral prospecting control should be even tighter than this. This procedure would minimize the statistical error so evident on existing maps. The old style loop control for reconnaisance work is outdated. Stations should be spaced homogeneously rather than being limited to county roads which sometimes form loops several miles in diameter. Within these loops absolutely nothing is known about the potential field until it is measured by the gravity meter. Wherever possible stations should be aligned in a network of straight rows so that this unsmoothed data may be used in profile analysis without destroying the directional property of the observed gradient. This type of control has probably never been obtained over any considerable area and for economic reasons may never be, but to the farsighted men who approach it, the rewards will be bountiful. ★ ★ ★

Tekoil Buys Wells For Possible Miscible Phase Tests

Purchase by Tekoil Corporation of 34 producing oil wells in Oklahoma's Sunflower Pool, which may offer the perfect test laboratory for a new displacement theory promising up to 100 percent recovery of oil in place, has been announced in Dallas by W. H. Davison, Tekoil president.

Purchase price involved oil payments and an undisclosed cash consideration. Now producing an average of 50 bbl daily from the Checkerboard formation at a depth of 3900 ft, the wells were acquired from E. L. Oliver, Davis Investment Company and the Muter Company.

Development plans call for expenditure of $100,000 to drill 10 additional wells in the Lincoln County field, along with the possible institution of the miscible phase displacement process for boosting recovery of oil in place.

An engineering study of the feasibility of initiating the process was begun by Tekoil several weeks ago at the request of another major producer in the Sunflower Pool, Davison declared.

All facilities needed for testing this process are on hand at the new properties, he said, including an easily accessible natural and propane gas supply.

Miscible phase displacement involves propelling a slug of enriched gas (propane or butane) through a formation to wash out the oil in the same manner kerosine removes excess oil from a sponge. Tests already underway give hope of recovering from 80 to 90 percent of the oil in place and, in some instances, as much as 100 percent. Current methods of secondary recovery including waterflooding claim recovery of no more than 50 percent of the oil in place.

The additional expenditures involved in the Sunflower project put Tekoil's development budget over the million dollar mark for the fiscal year beginning April 1. A $925,750 program calling for drilling 33 wells and initiating six water-flood programs in four states was announced by Tekoil.

Tekoil Corporation, an independent oil and gas producing company, specializing in secondary recovery, maintains executive offices in Dallas, engineering offices in Oklahoma City and operates in the states of Texas, Oklahoma, Illinois, Indiana, Kentucky, Louisiana, New Mexico, and Kansas.

FUNDAMENTAL DESIGN OF

Gas Lift Systems

Continuous gas lift, intermittent lift, or plunger lift? This article is an outstanding summary of the principles that govern this selection

C. V. Kirkpatrick
Chairman, Department of Petroleum Engineering
University of Houston

TERMS

GOR — Gas Oil Ratio
PI — Productive Index
BHP — Bottom-Hole Pressure
GFR — Gas Fluid Ratio

SEVERAL factors must be considered when selecting a method of artificial lift for a given well or well systems. As gas lift is one method in wide spread use today, let us look at some of the factors that govern its selection. Advantages of gas lift are: (1) Low initial and operating cost. This is particularly so in areas where high pressure gas is available; (2) flexibility of production. Gas lift can produce wells at very high rates of flow or at very low rates of flow. It can effectively produce high GOR wells; (3) deep wells, wells with crooked well bores, and wells with high water cut, can all be efficiently produced; (4) subsurface equipment used can be adapted to wire-line workover techniques, thus permitting economic operation and servicing; (5) gas lift has been successfully extended to dually completed wells, and (6) closed rotative systems have extended the operation to many areas where high pressure field gas is not available.

Factors that limit or impair the efficiency of gas lift are: (1) Sour gas; (2) wet gas subject to freezing; (3) paraffin, and (4) very low gravity crudes.

Application of Gas Lift

There are four well categories to be considered in gas lift application.

1. High PI — high bhp;
2. High PI — low bhp;
3. Low PI — high bhp;
4. Low PI — low bhp.

Terms high and low are relative. Any attempt to assign fixed values for delineation is meaningless for individual wells. For the purpose of this discussion, however, a low PI will mean 0.50 bbl per day per psi or less and low bhp will refer to 1000 psi or less.

Wells designed for continuous flow gas lift are normally those with a high PI — high bhp and those with a low PI — high bhp. In the latter case, the PI must not be too low (0.20 or higher) and the available injection pressure must be sufficiently high.

Wells designed for intermittent flow gas lift normally fall in the low PI — low bhp, and low PI — high bhp categories.

Decision as to whether or not the well should be produced continuously or intermittently for low gross fluid flow rates (i.e. less than 250 bbl per day) depends primarily upon two factors. Factor one is availability of gas. Producing method which will give the lowest gas/fluid ratio may govern the

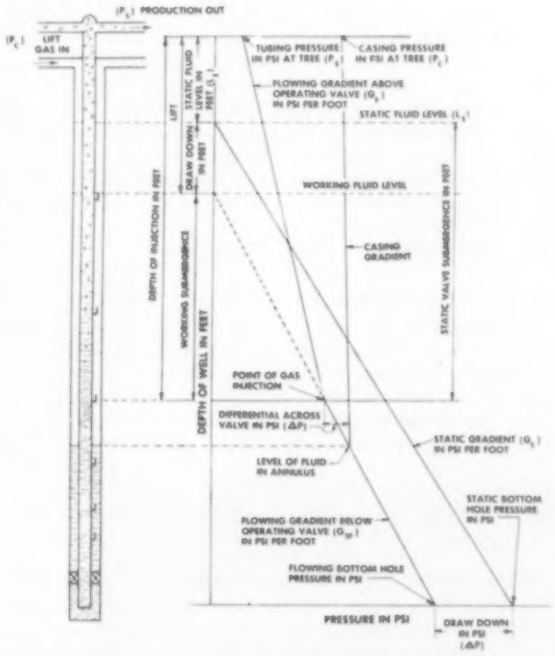
PRODUCTION OUT
LIFT GAS IN
TUBING PRESSURE IN PSI AT TREE
CASING PRESSURE IN PSI AT TREE
FLOWING GRADIENT ABOVE OPERATING VALVE IN PSI PER FOOT
STATIC FLUID LEVEL
WORKING FLUID LEVEL
CASING GRADIENT
DEPTH OF INJECTION IN FEET
WORKING SUBMERGENCE
DEPTH OF WELL IN FEET
STATIC VALVE SUBMERGENCE IN FEET
POINT OF GAS INJECTION
DIFFERENTIAL ACROSS VALVE IN PSI
STATIC GRADIENT IN PSI PER FOOT
LEVEL OF FLUID IN ANNULUS
STATIC BOTTOM HOLE PRESSURE IN PSI
FLOWING GRADIENT BELOW OPERATING VALVE IN PSI PER FOOT
FLOWING BOTTOM HOLE PRESSURE IN PSI
PRESSURE IN PSI
DRAW DOWN IN PSI

FIG. 1. Graphical factors and terms involved in continuous gas lift operation.

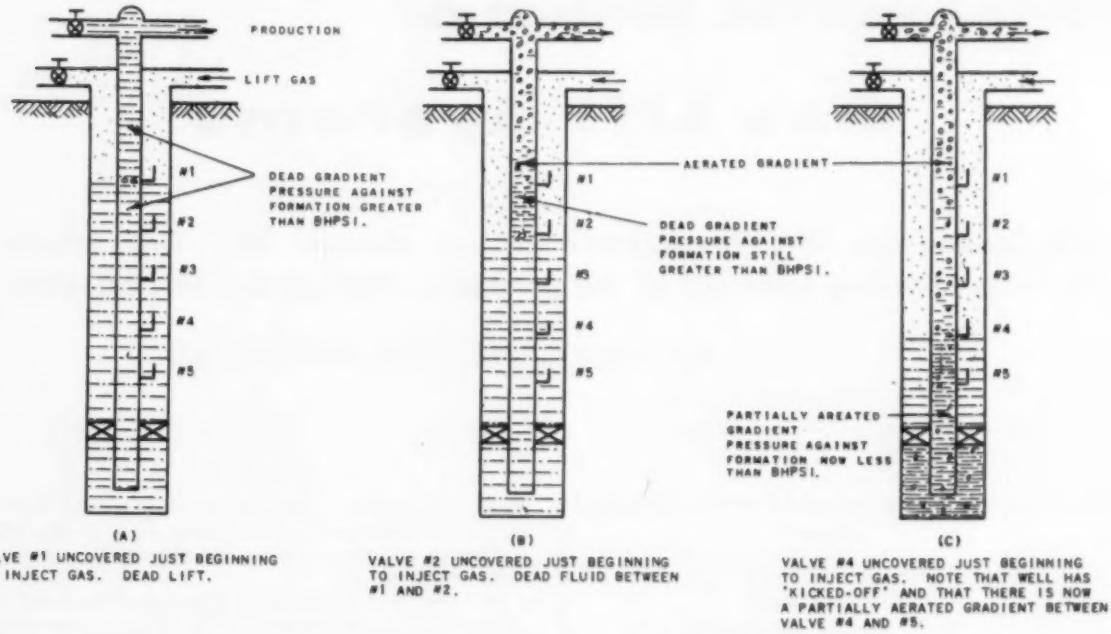
PRODUCTION
LIFT GAS
#1
#2
#3
#4
#5
DEAD GRADIENT PRESSURE AGAINST FORMATION GREATER THAN BHPSI.
AERATED GRADIENT
DEAD GRADIENT PRESSURE AGAINST FORMATION STILL GREATER THAN BHPSI.
PARTIALLY AERATED GRADIENT PRESSURE AGAINST FORMATION NOW LESS THAN BHPSI.
(A)
VALVE #1 UNCOVERED JUST BEGINNING TO INJECT GAS. DEAD LIFT.
(B)
VALVE #2 UNCOVERED JUST BEGINNING TO INJECT GAS. DEAD FLUID BETWEEN #1 AND #2.
(C)
VALVE #4 UNCOVERED JUST BEGINNING TO INJECT GAS. NOTE THAT WELL HAS 'KICKED-OFF' AND THAT THERE IS NOW A PARTIALLY AERATED GRADIENT BETWEEN VALVE #4 AND #5.

FIG. 2. Steps in well unloading firmly demand correct valve spacing. Spacing is determined by various fluid gradients.

operation. Factor two is the necessity to avoid excessive drawdown and possible damage to the reservoir in certain types of wells. For example, a high bhp — low PI well could be produced continuously at a rate of 100 bbl per day with a constant bottom-hole flowing pressure drawdown, whereas this same rate, produced intermittently, would result in much lower instantaneous bottom-hole flowing pressures.

Development of a reliable flowing gradient correlation which allows gradient prediction by calculation has greatly extended the scope of the gas lift application.

Basically, the gas lift application considers: (1) Continuous flow well systems; (2) intermittent flow well systems; (3) special applications such as dual completion and rotative systems, and (4) future developments.

Continuous Flow Gas Lift Wells

A continuous flow gas lift well may be represented as shown in Fig. 1. This figure shows both schematically and graphically the factors and terms involved in the operation. To design such an installation, one must know: (1) Gas injection depth, pressure, and GFR for the desired production (determined by calculation); (2) principles of the unloading operation; (3) well gradients; (4) gas lift valve spacing principles; (5) types of gas lift valves; (6) mechanics of gas lift valve operations, and (7) factors that affect continuous flow gas lift efficiency.

Determination of Gas Injection Depth, Pressure, and GFR.

Gas injection depth, pressure, and GFR can be accurately calculated for a desired producing rate if the well PI is known. This determination uses the calculated gradient technique and has been adequately described in previous publications. If the well PI is currently unknown, it can be reasonably estimated from previous well history by this same method of calculation.

Unloading

Consider the well installation shown in Fig. 2 (A) (B) (C). As casing pressure is applied to the annulus, all valves in the string are open and the fluid is "forced" or U-tubed into the tubing through open valves. As the first valve is uncovered, gas is injected into the solid liquid column above the valve in the tubing. Tendency will be for this head to be removed first as a slug and then as an aerated column. As the casing pressure is higher than the tubing pressure at any point, the liquid level will continue to be depressed until the second valve is uncovered. (All covered valves are open.) The pressure at this point will probably be in excess of the shut-in bhp of the well but liquid phase will still be feeding

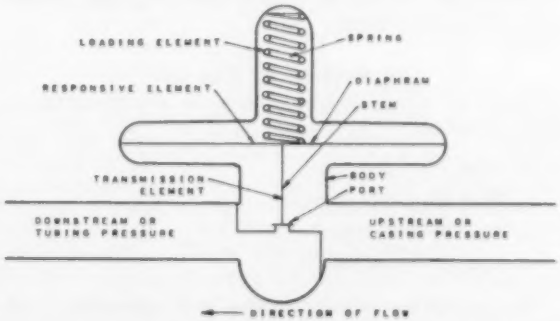

FIG. 3. Simple back pressure regulator. Force of upstream pressure causes regulator to pass gas when pressure force exceeds that of spring.

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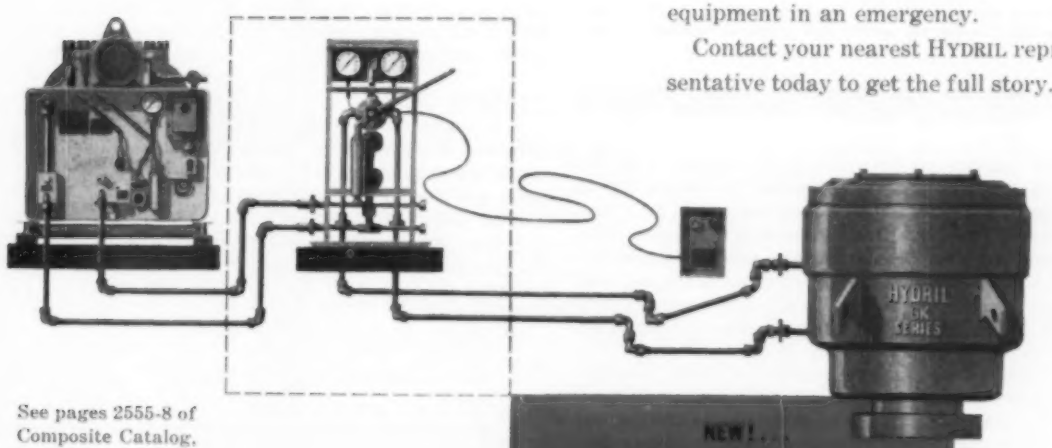

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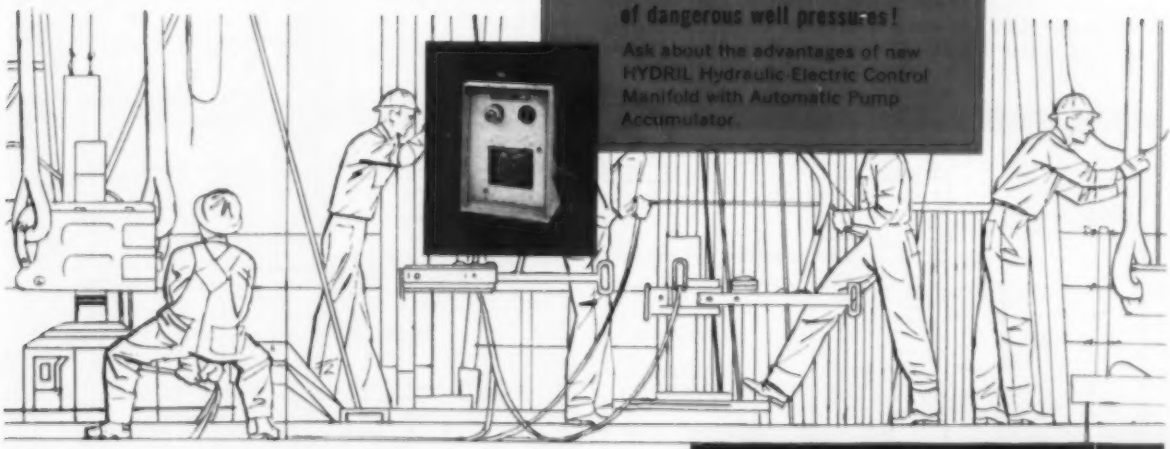

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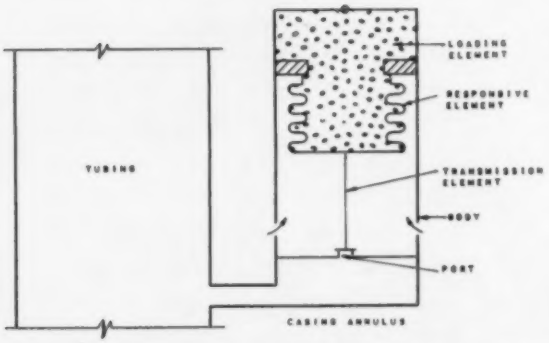

FIG. 4. Simple charged gas lift valve. Operation is similar to that of back pressure regulator except that spring is replaced by gas charge.

past valve number one by virtue of the transfer from the annulus through the lower open valves. Therefore, just as the number two valve is uncovered, there will be a two-phase flowing gradient above the number one valve and a non-aerated flowing gradient between valves one and two.

Valve number two will now go into operation and both one and two will temporarily pass gas. This specific condition does not necessarily hold for all valve unloading designs. With a properly sized choke in the input casing line, the gas will be passing into the tubing at a higher rate than it is being fed into the casing, and consequently, the pressure in the annulus will begin to drop. As the number one valve has a higher operating closing pressure setting than valve number two, it will close-off and number two will continue to pass gas. Valve number two will pass gas until number three is uncovered and begins to operate. The cycle will then repeat itself. At some intermediate valve operating point, the well will "kick-off" (reservoir fluids begin flowing into the well bore). Location of this point is important in certain valve spacing procedures. Throughout this unloading phase, successive valves are spaced closer together because of the heavy liquid unloading gradient between valves. After the well has kicked-off, however, this liquid gradient between valves becomes partially aerated and, depending on the well producing characteristics, the valves may sometimes be spaced with *increasing* distances between them. The degree of aeration is much less in wells making appreciable amounts of water, and is neglected in this type of well.

The well will now work down automatically to the operating valve where gas will be injected continuously. This will be the point at which the pressure in the tubing opposite the operating valve, plus the differential across the valve, is equal to the casing pressure opposite the valve.

In some continuous unloading operations it may be necessary to drop the casing injection pressure as each successive valve is uncovered, in order to close-off the upper valve. Also, a packer and tubing standing valve may be used in certain wells where the formation readily takes fluid.

Well Gradients

A fundamental understanding of the well gradient is imperative for optimum gas lift design. Distinction must be made between flowing well gradients for valve spacing purposes and flowing well gradients for ultimate gas lift production design. In the case of the continuous unloading operation just described [see Fig. 2(B)], it can be seen that the pressure in the tubing opposite valve number two, just before it is exposed to casing annulus gas, is made up as follows:

1. Tubing wellhead pressure;
2. Aerated flowing gradient above valve number one, and
3. Non-aerated *flowing* gradient between valves one and two.

Therefore, in spacing number two valve, an approximation of these gradients must be made. This is most often a dead lift at this point. That is, the well has not kicked-off and the aerated gradient is being sustained above valve one

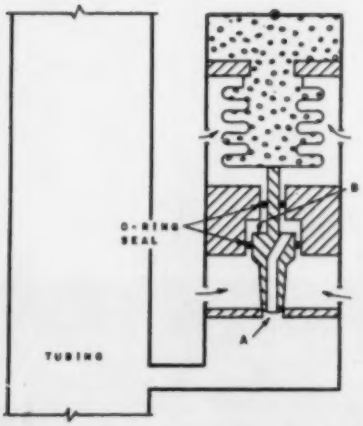

FIG. 5. Gas lift valve with pressure balanced. Balancing permits large orifice openings with complete control of opening by casing pressure.

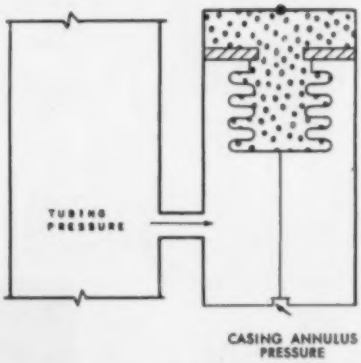

FIG. 6. Schematic diagram of fluid or tubing pressure operated valve.

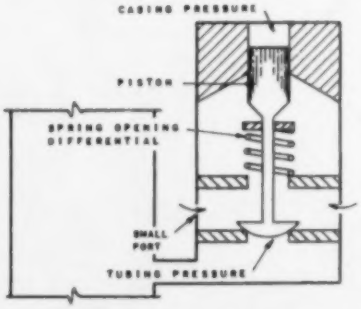

FIG. 7. Spring loaded type differential valve. With equal valve areas, higher pressure in tubing plus spring opens valve.

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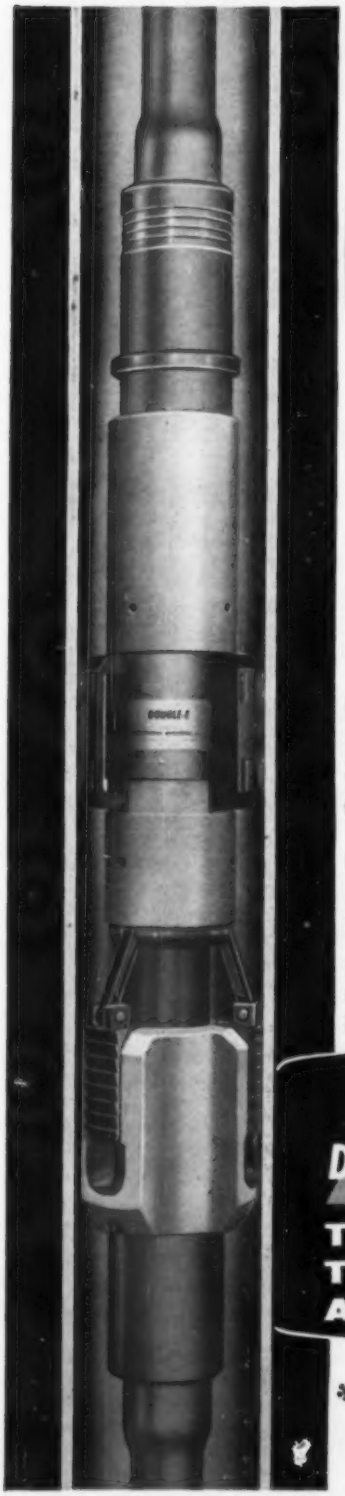

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HOW TO USE IT: Install the tension tubing anchor above or below the pump – or at any desired depth. Set the tool by rotating the tubing a partial turn to the left. Then exert an upward pull on tubing string. The tubing is now anchored in tension.

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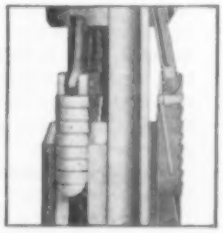

HOW TO RETRIEVE: Simply lower and rotate the tubing a partial turn to right and anchor is re-jayed. If re-jaying is impossible, merely exert a straight-up pull *in excess* of the Slip Failure Rating*. The Double-E Tension Tubing Anchor is designed so the slip-flanges shear upon excess pull. This releases the slips and the tubing string can be easily retrieved without loss of parts in the hole.

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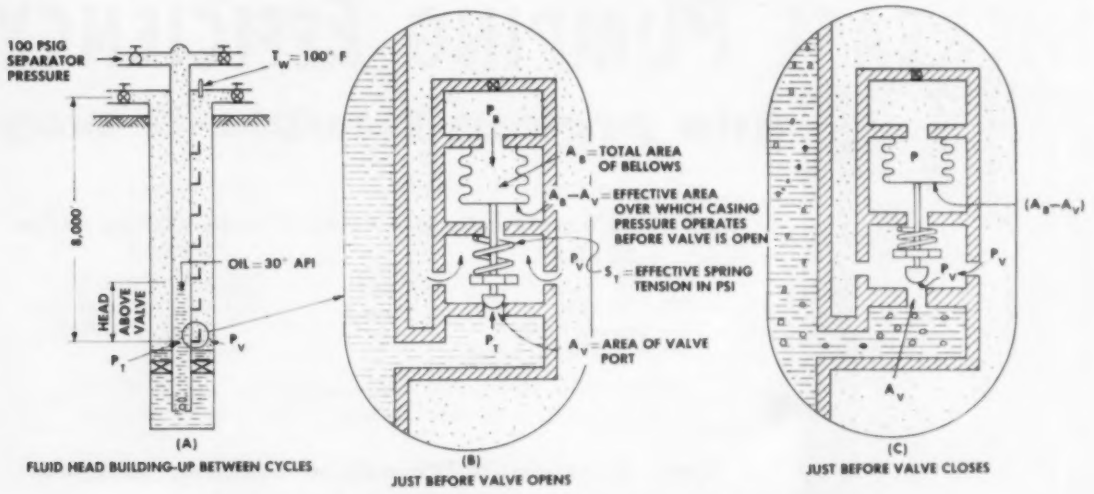


FIG. 8. Schematic diagram of valve operation used in calculating valve spread.

only by the transfer of *dead* liquid phase from the casing annulus. The aerated gradient is light because of the high percent volume gas phase and the relatively small amount of liquid phase. It is significantly less than the aerated gradient resulting when design production is being obtained from the final operating valve.

The flowing gradient between valves one and two is a heavy gradient and is approximately a dead liquid gradient for wells that do not kick-off from the first valve.

The operating gradient picture becomes quite different, however, once the well kicks-off and continues to work down toward the final operating valve. Now the aerated flowing gradient above the intermediate injection valves begins to increase. This is because of the higher average pressure in this section of the tubing which keeps more formation gas in solution, and the greater volume rate of liquid phase that the formation is now adding to that being transferred from the annulus.

The flowing gradient between the valve passing gas and the one below that is just before coming into operation, is now a partially aerated gradient. This may be a much lighter gradient than that for dead liquid.

Therefore, it is noted that the flow gradients which govern valve spacing for continuous unloading are constantly changing. The aerated gradient becomes progressively heavier and the non-aerated gradient becomes progressively lighter.

Selection of aerated flow gradients, based on the final gradient resulting from production, and non-aerated gradients, based on dead liquid, will often result in a much closer valve spacing than necessary. This is a common limitation in the conventional valve spacing approach. Flowing gradient information generally available for continuous unloading is the final gradient for low GFR wells producing high water cuts, and as a consequence, is always high for most valve spacing purposes.

Valve Spacing Principles

Optimum valve spacing principles require a knowledge of: (1) Well unloading characteristics; (2) well gradients, and (3) types of valves and the mechanics of their operation.

Conventional valve spacing formulae may be readily derived with the aid of Fig. 2(B). A knowledge of the types of valves and their operating characteristics will allow more flexible spacing designs than those obtained by the straight conventional spacing technique and consequently more efficient operations.

Types of Gas Lift Valves

As all valves contain similar basic operating characteristics, both continuous flow and intermitting types will be discussed under this heading.

All gas lift valves may be classified according to the type of service and the type of loading.

I. Type of service
   - A. Continuous flow
     1. Fixed orifice
     2. Variable orifice
   - B. Intermittent flow
     1. With minimum tubing pressure control
     2. With maximum tubing pressure control

II. Type of loading
   - A. Gas charged bellows chamber
   - B. Gas charged piston chamber
   - C. Gas charged rubber diaphram chamber
   - D. Spring
   - E. Spring, pilot-loaded
   - F. Combination spring and gas charged bellows
   - G. Liquid charged diaphram chamber
   - H. No loading pressure — mechanical operation

Gas lift valves, regardless of make, perform in accordance with certain basic operating principles. Simplest comparison is with a conventional regulator (see Fig. 3 and 4).

Controlling pressure for the gas lift valve acts over the large responsive element area, (bellows). If this area is large as compared to the valve port size, the tubing back pressure effect, acting to open the valve, will be small. A larger valve port for the same bellows area results in less pressure

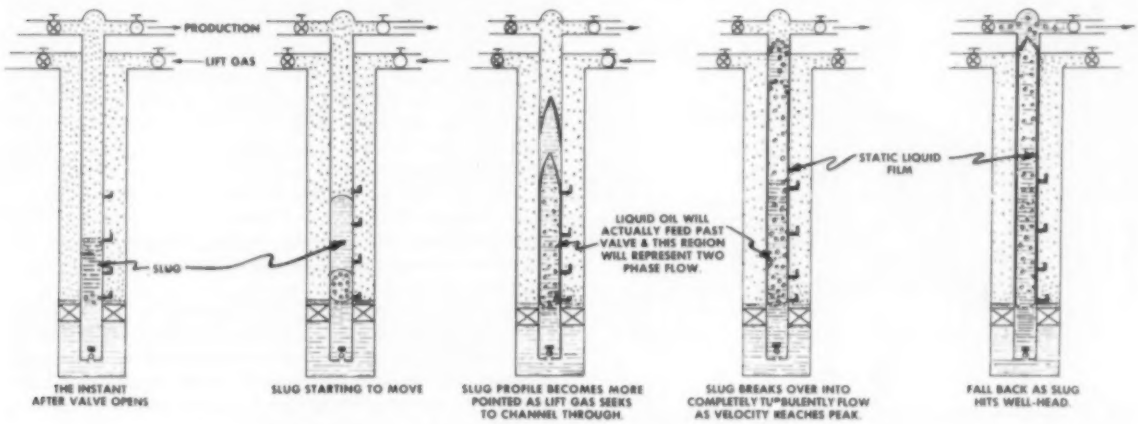

PRODUCTION
LIFT GAS
SLUG
STATIC LIQUID FILM
LIQUID OIL WILL ACTUALLY FEED PAST VALVE & THIS REGION WILL REPRESENT TWO PHASE FLOW.
THE INSTANT AFTER VALVE OPENS
SLUG STARTING TO MOVE
SLUG PROFILE BECOMES MORE POINTED AS LIFT GAS SEEKS TO CHANNEL THROUGH.
SLUG BREAKS OVER INTO COMPLETELY TURBULENTLY FLOW AS VELOCITY REACHES PEAK.
FALL BACK AS SLUG HITS WELL-HEAD.

FIG. 9. Progressive stages in intermittent flow. Producing rate is dependent upon fill-in and pressure of fluid column in tubing between slugs.

required in the casing to open the valve. This principle is used in the continuous flow valve, wherein a large port is used to get maximum tubing sensitivity and either a tapered valve stem or a fixed small orifice is used to restrict the input gas.

In certain designs, large port intermitting valves must minimize the tubing pressure effect. Unless a portion of this effect is "balanced" out, the valve will have an excessive spread. Spread is defined as the difference between the opening and closing pressure of the valve (see Fig. 5).

In the fluid operated type of valve, the tubing pressure becomes the controlling pressure. In order to achieve this result, the tubing pressure is directed against the large area of the bellows rather than across the inlet valve port. Hence for a given constant casing pressure, the valve can be set to open with a predetermined tubing head build-up (see Fig. 6).

Spring loaded differential valves like the fluid operated valve, use the tubing pressure as an aid in opening the valve. It differs in principle from the fluid operated valve in that both the loading force (spring) and the tubing force act to open the valve. Casing pressure furnishes only the closing force.

Mechanics of Gas Lift Valve Operation

Fig. 8 can be used to derive the formulae for the opening and closing pressures of a combination bellows and spring pressure charged gas lift valve. The opening pressure formula can be stated as follows:

Pressure required to open the valve is equal to:

(1) Pressure necessary to overcome the pressure charge inside the bellows;

(2) Full pressure effect of the spring, and

(3) Minus the *effective* tubing pressure helping to open the valve; or symbolically:

$$P_V = \frac{P_B}{(1\text{-}A_V/A_B)} + S_T - \frac{P_T\,(A_V/A_B)}{(1\text{-}A_V/A_B)}$$

where:

P_V = the casing pressure opposite the valve required to open it.

P_B = the pressure of the gas *inside* the bellows under operating conditions.

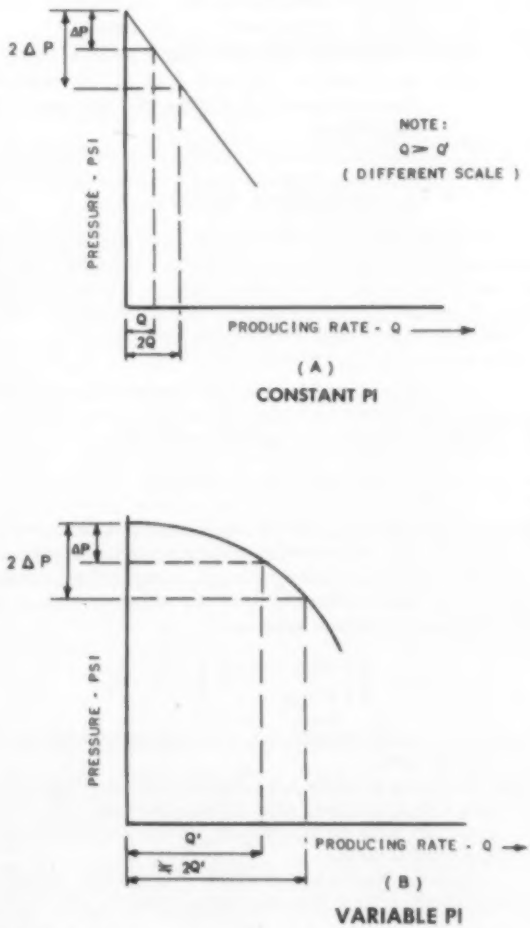


FIG. 10. Production vs drawdown for a constant and variable PI well.

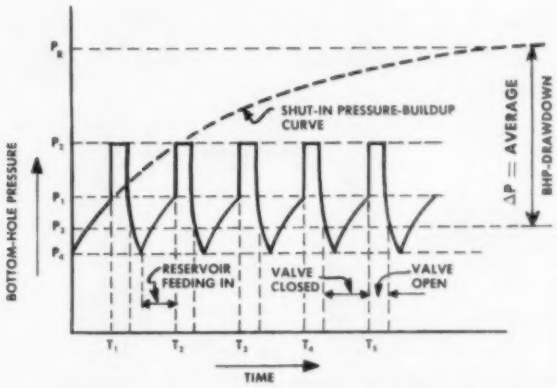


FIG. 11. Graphic representation of bottom-hole pressure of a well being produced by intermittent gas lift.

P_T = the operating pressure in the tubing opposite the valve just as it opens.

S_T = the full *pressure* effect of the spring.

A_V = the effective area of the valve port.

A_B = the maximum effective area of the bellows that is subjected to the gas pressure inside of the bellows.

A_V/A_B = the effective valve port to total effective bellows area ratio and is a manufacturer's constant furnished for different valves.

Closing pressure of the valve is, for practical purposes, independent of the pressure in the tubing, and therefore, is constant for a given operating condition. There are two ways to express the operating closing pressure of a valve, both having convenient particular applications.

The closing pressure may be expressed as:

1. The operating pressure *inside* the bellows plus the spring pressure effect multiplied by one minus the effective valve port to total effective bellows area ratio.

$$P_V = P_B + S_T\,(1\text{-}A_V/A_B)$$

This form of expressing the closing pressure is particularly convenient when using certain valve spacing techniques; or

2. The operating opening pressure without tubing pressure help multiplied by one minus the effective valve port to total effective bellows area ratio.

$$P_V = \left[\frac{P_B}{1\text{-}A_V/A_B} + S_T\right](1\text{-}A_V/A_B)$$

This form is useful for analyzing valve operation after being placed in the well.

As the closing pressure is a constant, the operating valve can always be determined from surface pressure data if the valves are set with an appreciable difference in their operating closing pressures.

Combination charts are available that greatly simplify the prediction of valve behavior under operating conditions.

Continuous Flow Gas Lift Efficiency

Continuous flow gas lift efficiency is interpreted differently in different areas. For example, in California and certain foreign countries where there is no prorated restriction of production, the optimum gas lift efficiency is that which will yield the lowest flowing gradient. Maximum drawdown will normally result in maximum production notwithstanding the high gas volumes required for the low flowing gradients. By contrast, in the Mid-Continent and the Gulf Coast, where the producing rates are restricted by proration, the optimum gas lift efficiency is usually that which produces the allowable with the minimum GFR. In many cases, detailed analysis by calculation is required to determine optimum operations for a given set of limiting conditions. In other words, the amount of gas available at a given pressure will be fixed. Therefore, the operation may represent maximum efficiency for the *given conditions*, but one whose efficiency could be *improved* if compressor selection were involved.

High injection pressures and single-point gas injection will yield maximum efficiency. Multi-point gas injection for continuously flowing wells is not as efficient as single-point injection. Recognition and control of the factors that influence the valve operation will give maximum efficient results.

Intermittent Flow Gas Lift Wells

Fig. 9 shows a conventional closed type of intermitting installation and Fig. 10 illustrates the effect of PI on producing rate.

Fig. 11 is a graphical picture of a hypothetical well being produced intermittently by gas lift. This plot shows bottom-hole pressure vs time with the injection cycle superimposed on the build-up curve.

1. Maximum reservoir build-up before each injection cycle is represented by P_1.

2. Because P_1 (bottom-hole pressure at the time the valve opens) is considerably less than P_R (stabilized shut-in bottom-hole pressure), the well liquid is feeding past the injection valve as the slug is being moved up the tubing. This is, of course, only true for this particular well example where the casing injection pressure is less than the flowing bhp.

3. Cycle frequency must be determined by the well's build-up ability between pressures P_4 (the point of maximum drawdown) and P_1. If the build-up curve is comparatively steep initially, then the frequency of the injection cycle may be relatively short. If the build-up curve is comparatively flat, then the frequency of the injection cycle must be correspondingly longer.

Optimum cycle frequency can only be obtained through multiple trials, because for any given well, the exact contribution of the PI is unknown. Actual well deliverability will depend largely upon the bottom-hole pressure drawdown, shown in Fig. 11. Basic

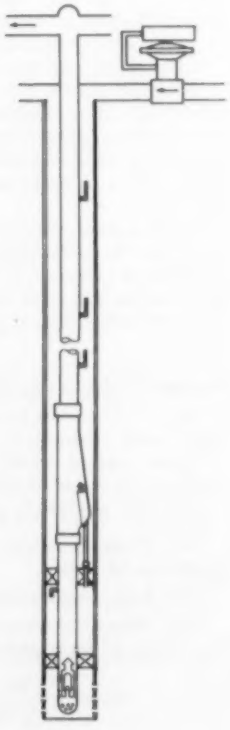


FIG. 12. Chamber gas lift installation. Principle is being extended to up-hole installations for better efficiency.

difference between the intermittent or ballistic type flow and continuous flow is again emphasized here. For continuous flow, it is *pressure* drawdown that causes the reservoir fluid to feed into the well stream and be simultaneously produced. The ballistic mechanism, however, depends on the reservoir feed-in due to pressure build-up from a relatively low pressure to a higher pressure.

Types of Intermittent Installations

There are basically four types of intermitting installations:

1. Conventional intermitting type, shown in Fig. 9. (Standing valve may not be required.)
2. Chamber type, shown in Fig. 12.
3. Gas lift plunger with an outside source of gas, Fig. 13.
4. Gas lift plunger where the well uses its own gas to unload the slug build-up.

In the conventional intermitting type of installation, several factors should be considered: First, the pressure differential required across the slug; second, the static liquid film (see Fig. 9) on the tubing as the slug surfaces, and third, the theoretical minimum gas requirements.

For any given well condition there is an optimum pressure differential for a given liquid slug build-up. Too high an injection pressure for a given head will cause the gas to channel completely through the liquid before it reaches the surface. This pressure will tend to maintain a stationary cylinder of liquid on the walls of the tubing (not to be confused with a wetting film as this annulus cylinder of liquid can be of appreciable thickness), and the gas will simply blow through and carry only a spray of oil out with it.

On the other hand, the injection pressure must be high enough to surface the slug without undue fall back. A minimum pressure differential of 25 to 50 percent of the slug head is necessary for efficient operations.

Theoretical minimum injection gas required is that necessary to fill the tubing from the bottom of the slug, just as the top hits the surface, to the operating valve. In areas of low geothermal gradient and when high gravity lift gas is used, the injection GFR will be greater than in operations where higher temperatures are encountered and lower injection gas gravities are used. This estimate can be the basis for determining the efficiency of the operation as installed.

Optimum design of this conventional intermitting installation requires the well to be valved as deep as necessary to keep the working pressure on the formation low enough for it to deliver the barrels of desired production between intermitting cycles. Many designs will require that maximum use be made of the tubing pressure in opening the valve. Optimum design will often require valve spacing that makes use of the valve surface closing pressure. Pressure charge of the first valve is selected on the basis of a predetermined operating spread.

Injection should take place from only one valve. This may require careful adjustment of the controller at the surface or even the use of a regulator in conjunction with the controller if small annulus volumes are involved. Slugs should be surfaced by gas *expulsion* and not gas *expansion*.

In summary, the design considerations for intermittent wells are as follows:

1. Kick-off gas pressure,
2. Continuous operating gas pressure,
3. High or low fluid level well,
4. High or low PI well,
5. Bhp build-up rate,
6. Available gas and the theoretical minimum gas requirement,

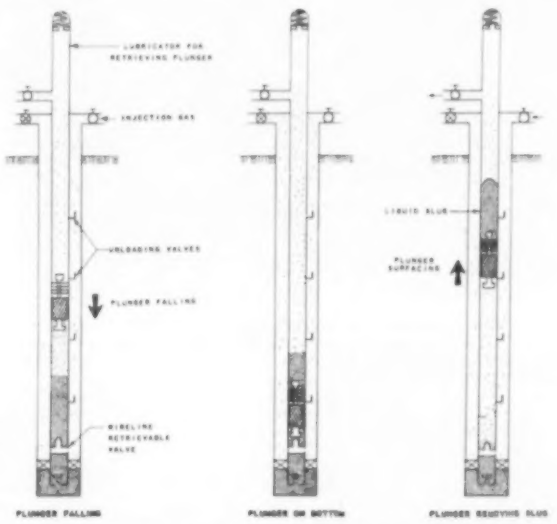


FIG. 13. Plunger lift with retrievable gas lift valve. Plunger reduces slippage per cycle encountered in conventional systems.

7. Production desired, and
8. Valve setting and spacing for unloading and operating.

Special Applications

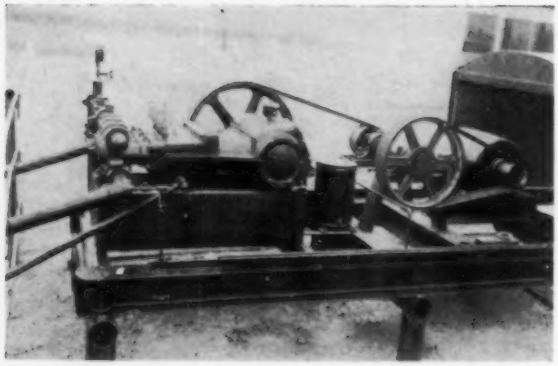
The number of dual completions, utilizing gas lift for one or both zones, is rapidly increasing. A number of satisfactory designs have been installed, but operating experience is still somewhat limited. Until more experience has been obtained, recommendations for optimum design must be very general. Applications to date have included the use of both parallel and concentric strings. Small diameter tubing is becoming more common.

Rotative gas lift systems are likewise on the increase. Very competent estimates can be made for these systems which will allow proper selection and sizing of compressors, and gathering and discharge line systems. Properly designed closed rotative systems have extended gas lift to areas where high pressure field gas is not available in sufficient quantities for lift purposes. Once the gas requirements for the closed rotative system have been fulfilled, the only outside gas necessary is nominal amounts for make-up gas. Rotative gas lift systems have promoted gas conservation and permit operators to utilize and sell formation gas when available in sufficient quantity.

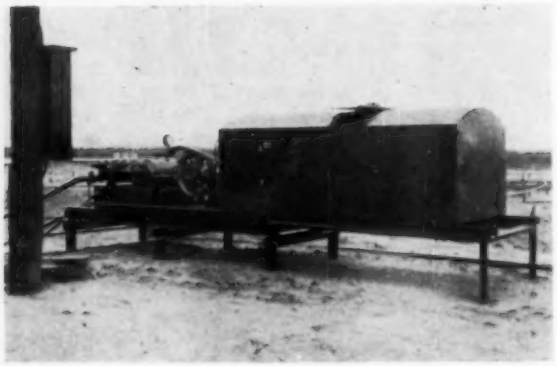
Future Trends

Future trends indicate the increased application of gas lift to dual completions and rotative systems. Design and development of small diameter tubing equipment, suitable for wire-line operation, is receiving concentrated attention. Refinements of present techniques involving the chamber gas lift installation designs are currently being made. Chamber principle is being extended to "up-hole" operations to improve the efficiency of conventional intermitting installations.

Improvement and extension of existing equipment, particularly in the area of wire-line application, and development of new operating techniques will be principal areas for improvement in gas lift operation.



Small triplex pump, a 10 hp electric motor, a chemical tank, and a drive shaft with an eccentric cam are basic components of this chemical additive unit. Unit is used in Karter-OK's salt water disposal system in North Texas.



Pump housing slides easily on and off the chemical additive pump unit using slide rails.

Field engineered . . .

Chemical Additive Pump

. . . Saves money, conserves power

INGENUITY in the oil field is commonplace, and perhaps not enough attention is given to the accomplishments of men who must solve the problems of lease operation. An example of this ingenuity is the way a North Texas independent operator tackled his salt water disposal problem.

Karter-OK Oil Company of Wichita Falls, Texas, was having a problem overcoming high pressure on their salt water disposal wells due to the presence of iron oxide that clogged the wells. With the addition of proper chemicals it was found that the injection pressure could be reduced from 660 psi to 350 psi, making possible the use of a smaller motor and a saving on power costs.

The problem was to find a good reliable method to add the chemical in just the proper amount to the water, because the chemical is expensive and no additional value is gained by an excessive amount. Triplex pumps with chemical injectors are available from the manufacturers, but this operator felt that his problem did not warrant additional expense of a factory-built unit.

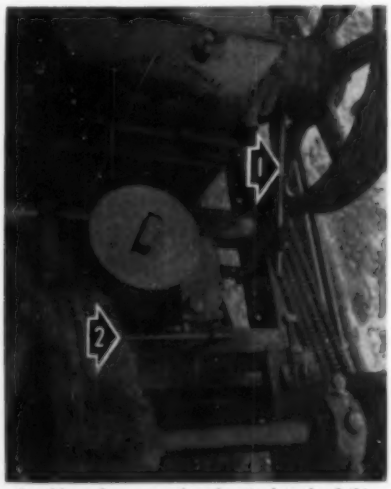
This operator had in operation on the lease a triplex pump, so he designed an eccentric cam to be mounted on the pump's drive shaft. An arm attached to the cam actuates the chemical feed pump to feed chemical into the suction line ahead of the triplex unit. To prevent the additive from being sucked into the line by the vacuum, a valve acting against a spring pressure of approximately 25 psi was placed in the discharge line of the chemical pump.

With this arrangement the Karter-OK Oil Company has been successful in limiting the amount of chemical added. Ratio of approximately one pint per 1400 gal of water, in this case, is the desired proportion.

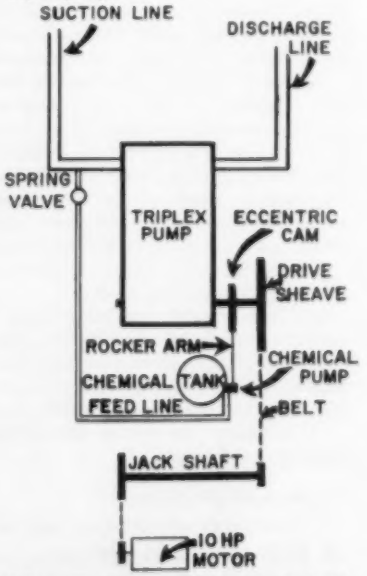
A sliding housing was built to cover the unit, and used another bit of originality by using "barn-door" type slide rails, inverted, on which to slide the steel housing. The slide-rails have rollers locked in so that wind cannot possibly lift the housing.

Three of these installations in operation, the other two being located in southern Oklahoma. Average installed cost of these installations is approximately $2200, complete with pump, feed pump, 10-hp electric motor and controls. Of this cost, the operator spent only $90 for the chemical pump, $18 for the "home-made" eccentric cam, and $7.50 for the piping and valve on the chemical feed line.

With the lower injection pressure made possible by the chemical additive, the cost of electric power is reduced, so that the capital investment is quickly regained out of operating savings. ★ ★ ★



Looking down on the chemical tank of this field engineered unit. Rocker arm actuates chemical feed pump (1). Feed line (2), injects chemical into suction line ahead of the triplex pump.



Schematic diagram of the chemical additive pump system. Note that a spring valve on the feed line, set a pressure of 25 psi, prevents additives being sucked into the line by vacuum.

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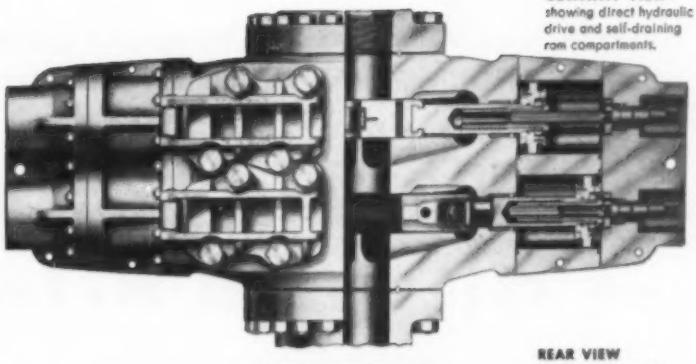
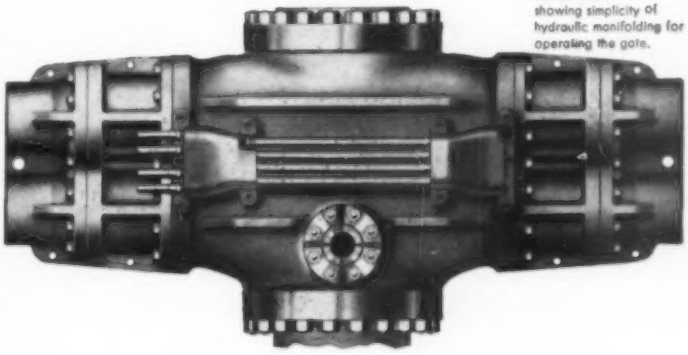


CUTAWAY VIEW showing direct hydraulic drive and self-draining ram compartments.



REAR VIEW showing simplicity of hydraulic manifolding for operating the gate.

Before you make your next investment in cellar control gates, take a moment to think through the various features you would like to have in those gates. You want protection, of course, but protection alone is only *part* of the story. You want such other important advantages as *Compactness . . . Simplicity of Ram Changes . . . Minimum Maintenance . . . Maximum Versatility* . . . and many others.

Then check ANY cellar control gate against the *multiple* advantages you get in Shaffer Hydraulic Cellar Control Gates and you'll see why Shaffer Gates are the top choice of leading operators throughout the oil industry. No other equipment offers *so many* design and performance features—in such a compact "package" as do Shaffer Hydraulic Gates.

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To begin with, Shaffer Hydraulic Gates are amazingly compact in all three dimensions—height, width and length. Even in sizes as large as 13⅝" (12" Series 900) Shaffer Hydraulic Double Gates require only 30" total height—Single Gates 18½".

In addition, there's no need to allow extra space above or at the ends in order to change rams, because Shaffer's exclusive side-opening doors through which the rams are changed open on the dimension where there's plenty of room. Thus, Shaffer's compactness is completely useable compactness!

You get

SINGLE or DOUBLE DESIGN

Some operators prefer Double Gates (two ram compartments unitized into one body) for their greater compactness in a multiple gate hookup. Others prefer the extra flexibility of Single Gates (use them singly . . . in pairs . . . or with a Double Gate for three-way protection). From Shaffer you get what YOU prefer—Double or Single—with both designs offering the same basic operating and construction features!

You get

EASY RAM CHANGES

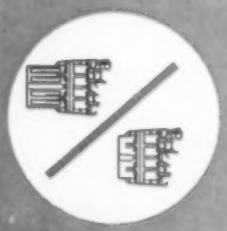
To meet requirements of varying pipe sizes as wells are drilled, the rams must be changed frequently. Shaffer Gates are unsurpassed in the ease with which the rams can be changed. Simply unbolt and open doors in the side of the gate body, slide out the ram assembly, change rams, slide the assembly back in place and bolt the doors shut. It's that simple.

What's more, rams can be changed with equal ease whether the pipe is in or out of the hole!

You get

SELF-DRAINING COMPARTMENTS

You want a gate where no detrimental mud or sand can accumulate to interfere with free ram travel—and Shaffer gives you this advantage, too. Note how the rams travel on guide ribs high above the steeply-sloped gate bottoms. Mud and sand quickly drain back into the well. Also, since well pressure is free to flow to the back of the rams, it actually assists in the closing and sealing action!



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THESE ARE ONLY PART OF THE COMPLETE SHAFFER STORY on design and operating advancements . . . advancements backed by the organization that pioneered cellar control gates more than three decades ago. Successful from the first gate built, Shaffer Gates have nevertheless gone through a continuous program of development that has kept them always ahead of the industry. That's why you get more features—plus operating flexibility to meet *your particular preferences* —when you specify SHAFFER. See your nearest Shaffer representative for further details—or write direct!

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Electric logs yield accurate formation porosity and interstitial water saturation data with these resistivity "keys"

Electrical Resistivities of Oil Field Brines

IN NORTHEAST TEXAS

Murphy E. Hawkins
Petroleum Engineer
U. S. Bureau of Mines
Dallas, Texas

FIG. 1. **Twenty-nine counties** in Northeast Texas are included in this special Bureau of Mines Study. These oil-productive counties are in the Texas Railroad Commission's Districts 5 and 6.

Editor's Note: "Electrical Resistivities of Oil Field Brines in Northeast Texas" is the third and most recent in a series of such reports made by the U. S. Bureau of Mines. These articles represent a very necessary service to obtain optimum results from electric well logs in their respective areas. *The Petroleum Engineer* published the first, "A Survey of Resistivities of Water from Subsurface Formations in North Texas," in December 1952. The second was "Electrical Resistivities of Oil Field Brines in South Arkansas and North Louisiana," published by *The Petroleum Engineer* in July and August, 1956.

DURING the past few years the electric log has become more than a correlation or qualitative tool to the oil and gas industry. When properly analyzed with reliable resistivity data an electric log will give quantitative information about formation porosity and interstitial water saturation. Essential resistivity factors needed in making quantitative analyses of electric logs are: (1) Knowledge of the resistivity of the interstitial water; (2) knowledge of the formation factor, and (3) knowledge of the true resistivity of the formation.

This report illustrates how the resis-

tivity of waters from the major oil-productive formations in Northeast Texas may be applied in the quantitative interpretation of electric logs from wells drilled in this area. Formation-water resistivity is also useful in many instances for determining casing leaks and as an aid in correlating geologic formations. Requests for previous reports on water resistivity[1,2] have indicated a need for this information by the oil and gas industry. Therefore, water resistivities have been compiled from 29 oil-productive counties in Railroad Commission of Texas Districts 5 and 6 (see Fig. 1).

The average water resistivities presented here represent measured and calculated resistivity of produced brines from approximately 2200 oil wells in the 123 fields included in this study. Water samples were collected from wellheads and separators when possible. Each resistivity included in this report was compared with that resistivity of other water samples produced from the same formation within each field or local area. All doubtful resistivities were omitted from the average value shown for each formation in the accompanying tables. Samples from drillstem tests usually were discarded because of possible contamination by drilling muds. Samples were not obtained from gas or gas-condensate fields, because of the likelihood of dilution by water condensed from the vapor carried up the hole with the gas.

Definition of Water Resistivity

Resistivity of water is defined as the property of water that restricts the flow of an electric current. Unit generally employed to express water resistivity is the ohm-meter (ohm-m). This unit expresses the resistance, in ohms, of 1 cu meter of water to the flow of a uniform electric current parallel to one side of the cube. Water resistivity may also be expressed in ohm-meters squared per meter (ohm-m²/m), or in ohm-centimeters (ohm-cms).

In electrolytic conductors, such as formation waters, the resistivity decreases with increase in temperature, as shown by the curves in Fig. 2. All water resistivities in this report have been adjusted to 75 F for correlative purposes. Before these values are used in electric log interpretations, they must be adjusted to the appropriate formation temperature by using the curves in Fig. 2.

Methods of Determining Water Resistivity

Direct measurement of water resistivity. The simplest and most accurate method of finding the resistivity of water is by direct measurement of sam-

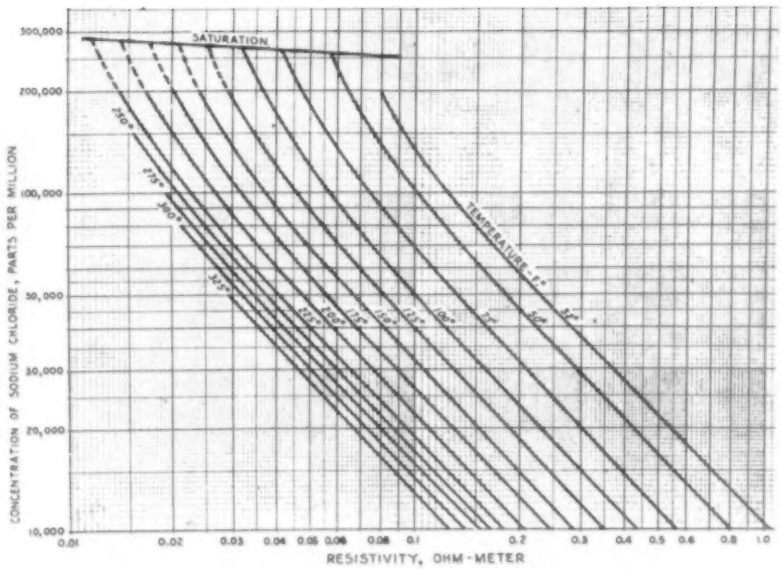

FIG. 2. **Resistivity relation** to temperature and concentration of sodium chloride solutions.

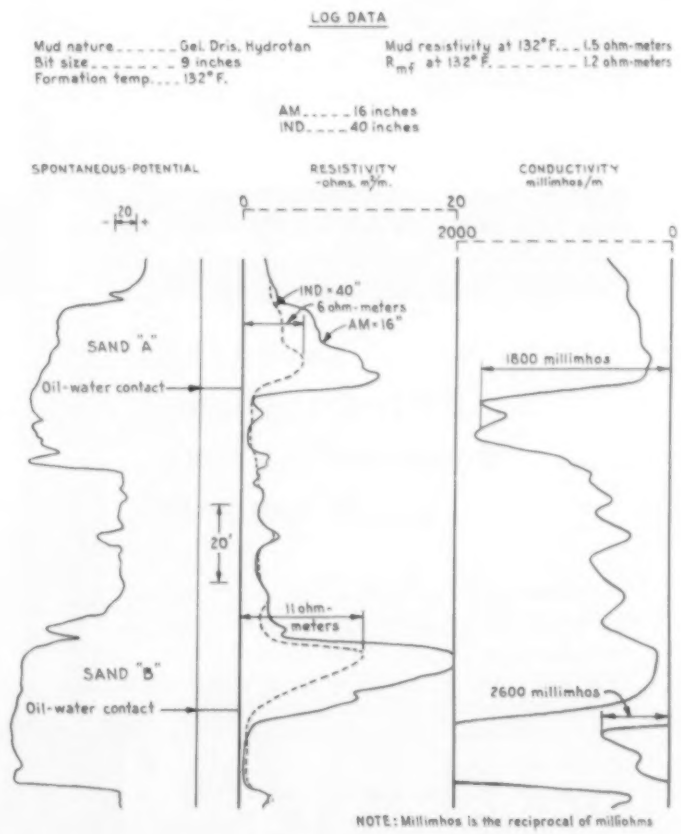

FIG. 3. **Electric-induction log** from the Woodbine formation, Cayuga field, Anderson County, Texas.

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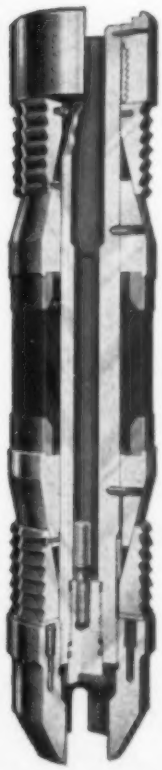

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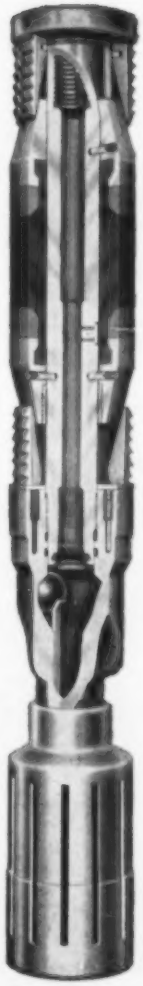

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ples with a resistivity meter. All samples collected for this study were measured with a resistivity meter (Schlumberger electronic portable mud tester, type EMT-A), and the resistivities obtained were adjusted to a temperature of 75 F by using the curves in Fig. 2.

Calculating resistivity from mineral analyses of water. Several methods have been published for calculating the resistivity of water from water mineral analyses. A method developed by Dunlap and Hawthorne[3] was used in making the calculated resistivities included in this report. In this method multipliers are used to convert the concentration, in parts per million, of various ionic constituents of the water to equivalent sodium chloride (NaCl). Using the sum of the equivalent concentrations the resistivity of the water at the desired temperature can be read directly from the curves in Fig. 2. The deviation of calculated resistivities from measured resistivities may be caused by variation in ionic proportions of salts dissolved in the waters.

The multipliers and a sample calculation of a resistivity determination from a water analysis follow:

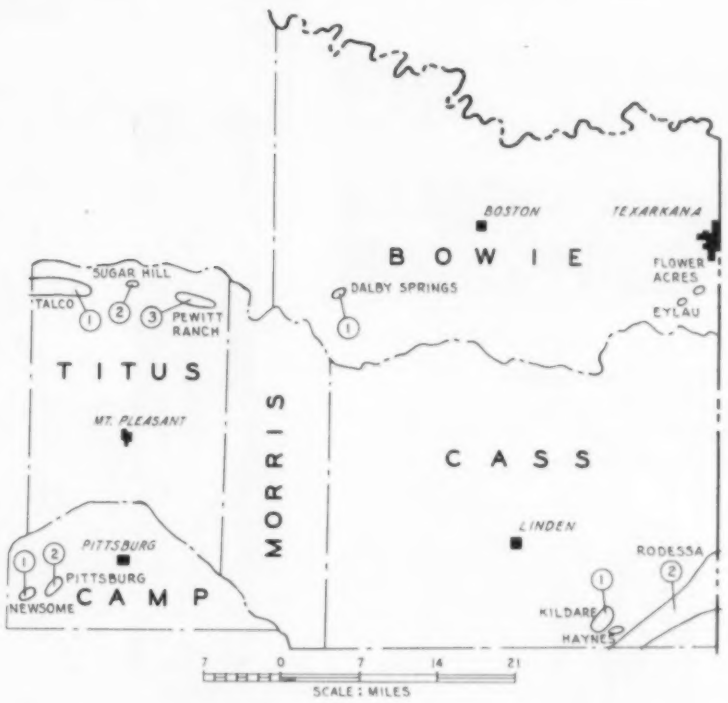


FIG. 4. **Source of water samples collected in Titus, Camp, Bowie, and Cass counties, Texas.**

Ionic constituent	Concentration parts per million	Multipliers	Equivalent concentration of NaCl, parts per million
Sodium, Na	26,200	1.00	26,200
Calcium, Ca	1,500	.95	1,425
Magnesium, Mg	315	2.00	630
Sulfate, SO_4	200	.50	100
Chloride, Cl	43,500	1.00	43,500
Carbonate, CO_3	0	1.26	0
Bicarbonate, HCO_3	573	.27	155
Total	72,288		72,010

Calculated resistivity (using Fig. 2) at 75 F = 0.097 ohm-meter
Measured resistivity at 75 F . . . . . = 0.099 ohm-meter

Estimating resistivity from the electric logs. Although the practical application of the spontaneous-potential curve (SP) is to distinguish between shale and nonshale formations, it may also be used quantitatively to estimate the resistivity of formation water. Wylie[4] states that there are several electrical components reflected in the SP curve, but the primary potential is of an electro-chemical nature. This relationship is expressed mathematically as:

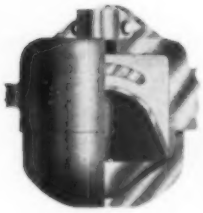
$$SP = K \log_{10} \frac{R_{mf}}{R_w}$$

where:

SP = magnitude of deflection of self-potential curve from the shale baseline on the electric log, in millivolts;

TABLE 1. Resistivity of Water Samples, Titus, Camp, Bowie, and Cass Counties, Texas.

Map Index	Field	Formation	Approximate depth, ft	Average resistivity R_w at 75 F, ohm-meter
		Titus County		
1	Talco	Nacatoch	900	0.241
1	Talco	Blossom	2240	.172
1	Talco	Sub-Clarksville	2400–2600	.153
1	Talco	Woodbine	3200	.116
1	Talco	Paluxy	4160–4360	.358
2	Sugar Hill	Paluxy	4380–4400	.283
3	Pewitt Ranch	Paluxy	4475–4600	.338
		Camp County		
1	Newsome	Sub-Clarksville	3850–3950	.100
2	Pittsburg	Pettet (Venters)	7850–8100	.047
		Bowie County		
1	Dalby Springs	Paluxy	4360–90	.248
		Cass County		
1	Kildare	Rodessa	5600–6000	.052
1	Kildare	Pettet	6670–6700	.050
2	Rodessa	Rodessa (Henderson-Gloyd zone)	5600–6000	.045
2	Rodessa	Rodessa (Dees-Young zone)	5700–6100	.044

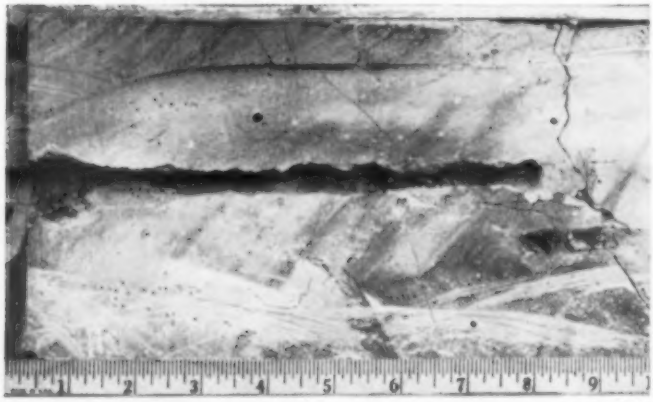


WELEX LINK-JET*

Leaves 40% Less Debris

The Welex 1-11/16" Link-Jet, the newest of the Welex jet perforators, has been designed to give more penetration with less debris than any other type tubing gun available. Engineered for use in small I. D. casing liners and tubing, the advantages of the Welex Link-Jet are many:

- Forty percent less debris than any type tubing gun.
- Greater penetration and hole size than any fixed-type tubing gun.
- Extreme flexibility permits passage through tight spots in casing and tubing.
- Elimination of debris from perforation.
- Bottom firing insures sure detonation of string.
- Unique design permits interval to be skipped at minimum expense.
- Welex Dyna-Jet principle in charge assures greater hole volume.
- Strong, light-weight construction permits perforation of large shooting zones in one run.



Welex 1-11/16" Link-Jet shot in ½" of fluid into ¾" steel plate and 14-day cement to give .40" entrance hole and 8" penetration.

WELEX 1-11/16" LINK-JET
Designed for use in Small Liners and Tubing

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TABLE 2. Resistivity of Water Samples, Hunt, Hopkins, and Franklin Counties, Texas.

Map Index	Field	Formation	Approximate depth, ft	Average resistivity R_w at 75 F, ohm-meter
		Hunt County		
1	Ashby-Ramsey	Woodbine	3210–30	0.467
2	Wieland	Woodbine	2770–2800	.418
		Hopkins County		
1	Birthright	Paluxy	4740–60	.551
2	Sulfur Bluff	Woodbine	2730	.138
2	Sulfur Bluff	Paluxy	4450–4550	.445
3	Mitchell Creek	Paluxy	4460–4550	.441
4	Como	Sub-Clarksville (Upper)	3970–4030	.106
4	Como	Sub-Clarksville (Coker)	4180–4200	.093
5	Pickton	Woodbine	4930	.079
5	Pickton	Paluxy	6330	.069
		Franklin County		
1	Lakeview	Paluxy	4420	.482
2	Talco	Nacatoch	900	.241
2	Talco	Blossom	2240	.172
2	Talco	Sub-Clarksville	2400–2600	.153
2	Talco	Woodbine	3200	.116
2	Talco	Paluxy	4160–4360	.358
3	New Hope	Woodbine	4450–4650	.086
3	New Hope	Rodessa (Bacon)	7220–7400	.048
3	New Hope	Rodessa (Hill)	7350–7450	.046
3	New Hope	Pettet (Pittsburg)	7850–8000	.044
4	Cornersville	Rodessa	7750–60	.046
4	Cornersville	Pettet (Pittsburg)	8260–80	.046

TABLE 3. Resistivity of Water Samples, Kaufman, Van Zandt, and Henderson Counties, Texas.

Map Index	Field	Formation	Approximate depth, ft	Average resistivity R_w at 75 F, ohm-meter
		Kaufman County		
1	Walter Fair	Woodbine	4160–4200	0.105
1	Walter Fair	Paluxy	4960–90	.440
2	Ham Gossett	Woodbine	3220–70	.174
2	Ham Gossett	Woodbine (Lewisville)	3400–3450	.159
2	Ham Gossett	Woodbine	3640–3700	.144
2	Ham Gossett	Woodbine (L. Dexter)	3980–4030	.126
2	Ham Gossett	Upper Glen Rose	5780–90	.071
3	Williams-Ham Gossett	Woodbine (Lewisville)	3230–80	.166
4	Southeast-Ham Gossett	Woodbine (Lewisville)	3230–50	.176
		Van Zandt County		
1	Myrtle Springs	Nacatoch	1500–1550	.380
1	Myrtle Springs	Woodbine	4620–4700	.087
1	Myrtle Springs	Paluxy	6320–40	.083
1	Myrtle Springs	Travis Peak	8525–50	.053
2	Fruitdale	Travis Peak	8552–70	.045
3	Van Shallow	Nacatoch	1246	.287
4	Van	Nacatoch	1200–1300	.270
4	Van	Woodbine	2850–2950	.098
		Henderson County		
1	Rowe & Baker	Woodbine	3140–90	.200
2	Flag Lake	Woodbine	2700–3100	.274
3	Opelika	Rodessa	8870–8950	.055
4	LaRue	Rodessa (Bacon limestone)	7760	.047
5	Tri-Cities	Rodessa	7680–7750	.049
6	South Malakoff	Rodessa (Bacon limestone)	7460–7550	.049
7	Cayuga Northwest	Rodessa	7440	.047
8	Frankston	James limestone	10,050-10,065	.047

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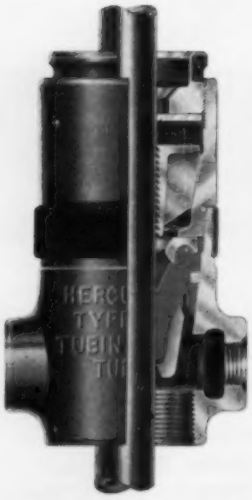

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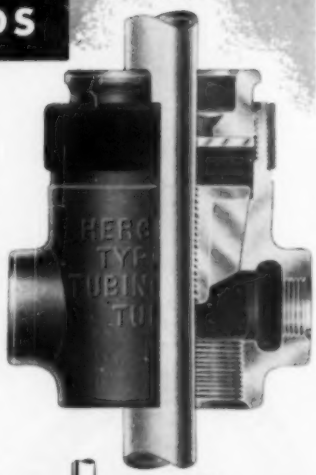
"TYPE J-5-S" STRIPPER TUBING HEAD

The dual purpose "Type J-5-S" Stripper Tubing Head is basically a "Type J-5" Tubing Head with a bowl (top section) screwed into the packing nut thread. The hinged slips, packing and packing nut are installed in the bowl (top section) with the tubing stripper in the body (lower section), thus permitting tubing to be run-in or removed under pressure. Test pressure is the same as the "Type J-5" Tubing Head.



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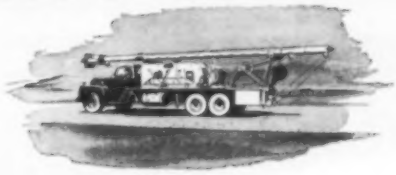

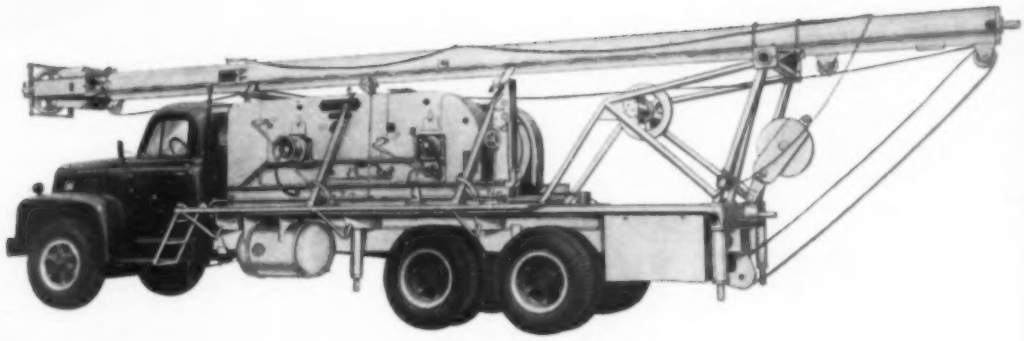

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K = correction factor ranging from −70 to −90 for clean sands, but as low as −50 for shaly sands, and to −110 for limestones;

R_{mf} = mud-filtrate resistivity, ohm-meters at formation temperature;

R_w = formation-water resistivity, ohm-meters at formation temperature.

Several features inherent in this relationship and the K factor (which may vary from −110 to −50) make unlimited use of the equation unadvisable and emphasizes the importance of reliable data. If the various parameters can be ascertained, however, a reasonable water resistivity can be estimated by rearranging and solving the equation.

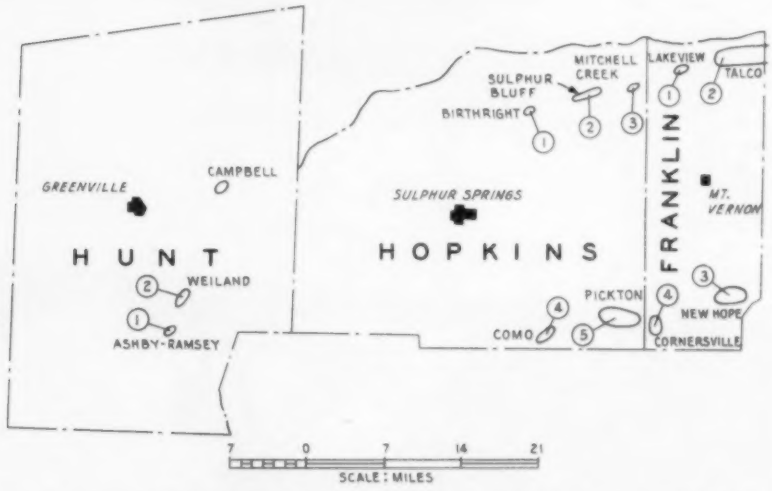

FIG. 5. **Source of water samples** collected in Hunt, Hopkins, and Franklin counties, Texas.

FIG. 6. **Source of water samples** collected in Kaufman, Van Zandt, and Henderson counties, Texas.

Application in Electric Log Interpretations

To illustrate the use of formation-water resistivity in quantitative analyses of electric logs, formation porosity and interstitial water were estimated from an electric log of a Northeast Texas oil well.

Archie[5] published the basic equations for quantitative analysis of electric logs where average porosity is expressed as a function of formation resistivity as:

$$P = \sqrt[m]{\frac{1}{F}} \quad . \quad . \quad . \quad (1)$$

where:

P = porosity expressed as a decimal fraction;

m = cementation factor of the formation (ranges from approximately 1.3 to 2.2);

F = formation-resistivity factor, which is a complex function of lithology.

Later, Winsauer, Sherin, Masson, and Williams[6] published what is generally referred to as the "Humble Formula," that relates the formation-resistivity factor of a clean sand to its porosity and tortuosity. This relationship using the same symbols as in Archie's equation expresses porosity by the following formula:

$$P = \sqrt[2.15]{\frac{0.62}{F}} \quad . \quad . \quad (2)$$

When the formation rock is completely saturated with formation water the following relationship exists:

$$F = \frac{R_o}{R_w} \quad . \quad . \quad . \quad . \quad (3)$$

where:

R_o = the resistivity of a formation rock when completely saturated with formation water, ohm-meters at formation temperature;

R_w = formation-water resistivity, ohm-meters at formation temperature.

Combining Equation 2 and 3 porosity is expressed as:

$$P = \sqrt[2.15]{\frac{(0.62)(R_w)}{R_o}} \quad . \quad . \quad (4)$$

In formations containing saline water with oil and/or gas, the true resistivity of the formation (R_t) will be higher than R_o because of the insulating properties of petroleum. The rela-

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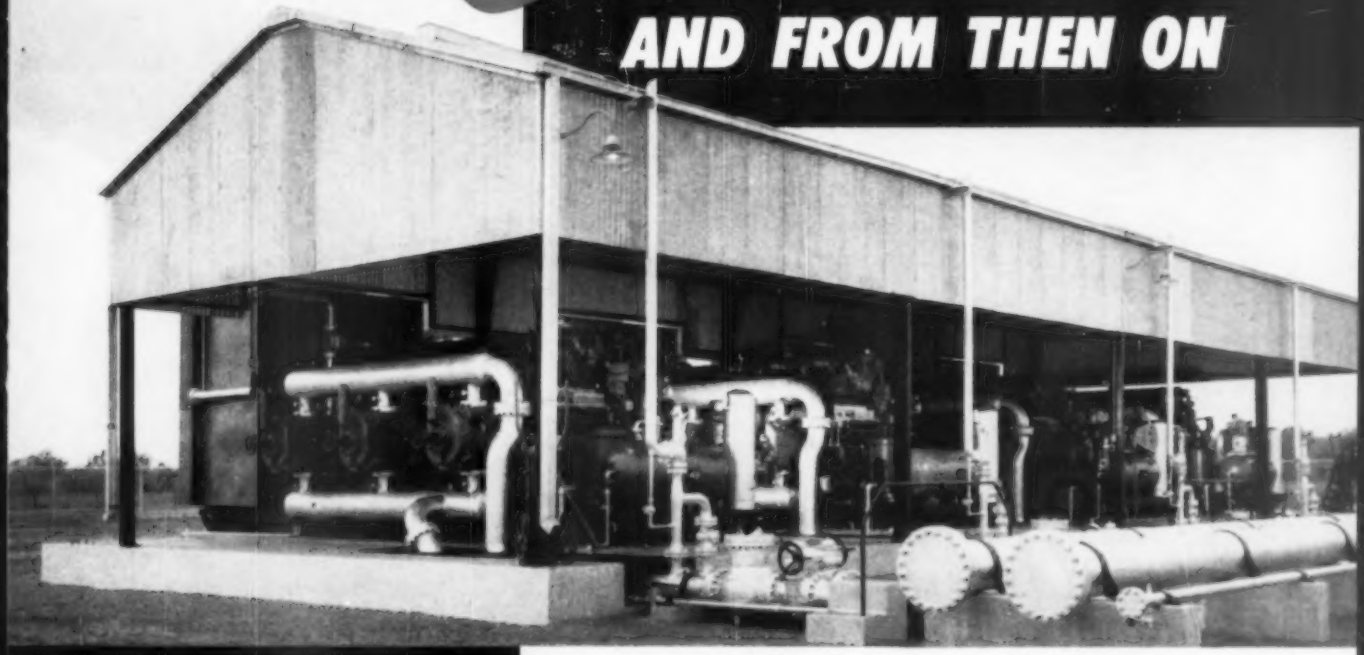

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Southwest packaged gas compressors for main line stations

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Southwest Packaged Gas Compressors for main line compression are **being** installed for **less than $200 per horsepower.** And they will be running months before field assembled units can be built!

Lower first costs are only part of the story. Unattended operation, possible with the automatic controls and safety devices on Southwest Packaged Compressor Plants, cuts operating cost per horsepower-hour to a fraction of the cost of a fully attended installation.

The final economy for your pipeline is that this station never need be shut down completely. In South Louisiana, the capacity of a main line station with eight 660 hp Southwest units, is reduced only 12½ per cent when one unit is down. However, if two 2600 hp units were used instead, capacity would be reduced 50 per cent when one unit is down.

These are all proved facts. Southwest engineers can show you the **results** and savings pipelines are realizing now with Southwest Packaged Gas Compressors.

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TABLE 4. Resistivity of Water, Samples, Wood and Smith Counties, Texas.

Map Index	Field	Formation	Approximate depth, ft	Average resistivity R_w at 75 F, ohm-meter
		Wood County		
1	Yantis	Eagle Ford (Blalock)	4170–4250	0.102
2	Coke	Sub-Clarksville	4020–4150	.101
2	Coke	Paluxy	6300–6400	.068
3	Manziel	Sub-Clarksville	4000–4100	.091
3	Manziel	Woodbine	4900	.076
3	Manziel	Paluxy	6300–6400	.064
3	Manziel	Rodessa	8450–8550	.045
4	Midway Lake	Sub-Clarksville	4430–4560	.092
5	Winnsboro	Rodessa (Young)	7840–60	.044
5	Winnsboro	Rodessa (Gloyd)	8260–80	.046
6	McCrary	Nacatoch	2300	.210
6	McCrary	Sub-Clarksville	4350–4450	.093
7	Alba	Sub-Clarksville	4100–4250	.103
8	Quitman	Eagle Ford	4230–4300	.090
8	Quitman	Woodbine	4350–60	.073
8	Quitman	Paluxy	6210–6370	.063
9	Forest Hill	Sub-Clarksville	4405–4500	.091
10	Merigale Paul	Nacatoch	2180–2250	.202
10	Merigale Paul	Sub-Clarksville	4750–4950	.088
10	Merigale Paul	Woodbine	5240–5488	.076
11	Nolan Edward	Sub-Clarksville	4660–4750	.104
12	Shirley Barber	Sub-Clarksville	5530–5480	.084
12	Shirley Barber	Sub-Clarksville (Harris sand)	5600	.083
13	Due Pree	Sub-Clarksville	5000–20	.087
14	Pine Mills	Sub-Clarksville (Upper)	4710–80	.089
14	Pine Mills	Sub-Clarksville (Orr sand)	4800–30	.090
14	Pine Mills	Woodbine	5350–5400	.085
15	East Pine Mills	Sub-Clarksville	4760–90	.090
15	East Pine Mills	Woodbine	5270–5410	.087
16	Earl Lee	Woodbine	5380–5570	.076
17	Trice	Woodbine	5660–80	.074
18	Hawkins	Woodbine	4790–4820	.074
		Smith County		
1	Mt. Sylvan	Nacatoch	2460–2650	.235
1	Mt. Sylvan	Paluxy	7340–7410	.075
2	Boynton	Paluxy	7460	.070
3	Bud Lee	Paluxy	7560–80	.074
4	Hitt's Lake	Paluxy	7130–7300	.070
5	Sand Flat	Woodbine	5550–5660	.072
5	Sand Flat	Paluxy	6950–7250	.071
5	Sand Flat	Rodessa	9330–40	.050
6	Manziel Bros.	Pettet	8050–60	.053
7	Chapel Hill	Glen Rose	7370–7720	.052
8	Tyler	Paluxy	7680–90	.069
9	South Tyler	James limestone	9920–10,000	.047
10	Good Omen	Woodbine	3950–4000	.099

FIG. 7. **Source of water samples collected in Wood and Smith counties, Texas.**

TABLE 5. Resistivity of Water Samples, Upshur, Gregg, Marion, and Harrison Counties, Texas.

Map Index	Field	Formation	Approximate depth, ft	Average resistivity R_w at 75 F, ohm-meter
		Upshur County		
1	East Texas	Woodbine	3600–3800	0.114
		Gregg County		
1	East Texas	Woodbine	3600–3800	.114
		Marion County		
1	Rodessa	Rodessa (Henderson-Gloyd zones)	5600–6000	.045
1	Rodessa	Rodessa (Dees-Young zones)	5700–6100	.044
2	Marion Shallow	Nacatoch	900–1100	.221
2	Marion Shallow	Paluxy	2300–2700	.142
		Harrison County		
1	North Lansing	Rodessa (Young)	7000–7080	.046
1	North Lansing	Pettet (Lower)	7500–25	.046
2	Woodlawn	Pettet	6630–6700	.048
3	Longwood	Goodland limestone	2350–2450	.153
3	Longwood	Pettet	5600–5650	.050
3	Longwood	Travis Peak	6010–30	.050
4	Waskom	Goodland limestone	2300–2400	.154
4	Waskom	Pettet (Upper)	5825–30	.046
4	Waskom	Travis Peak	6000–6200	.054
4	Waskom	Travis Peak (Hurley-Orr)	6200–6300	.047
5	Bethany-Panola	Goodland limestone	2400–2600	.137

tionship between formation resistivity and water saturation is expressed approximately by the following formula, which was developed by Archie:

$$S = \sqrt[n]{\frac{FR_w}{R_t}} \quad . \quad . \quad . \quad (5)$$

where:

S = formation-water saturation, expressed as a decimal fraction;

n = water-saturation exponent, depending upon the lithology of the rock (usually assumed to equal 2);

FIG. 8. **Source of water samples collected in Upshur, Gregg, Marion, and Harrison counties, Texas.**

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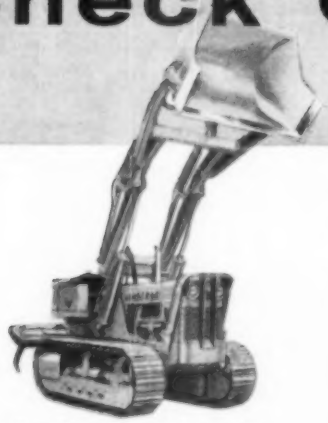

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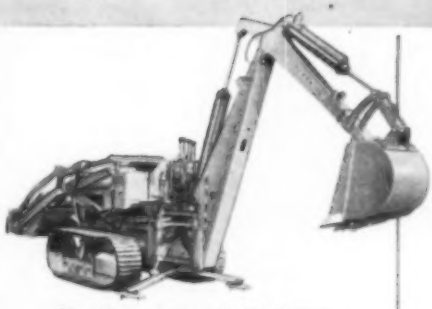

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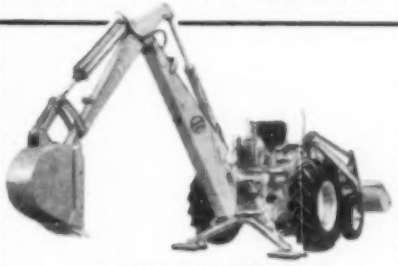

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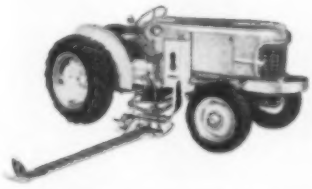

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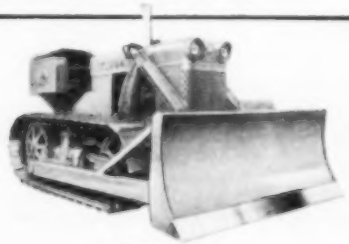

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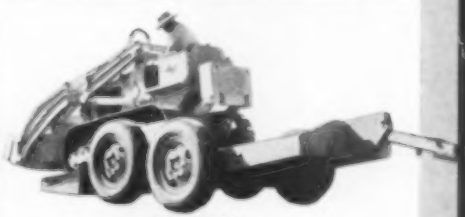

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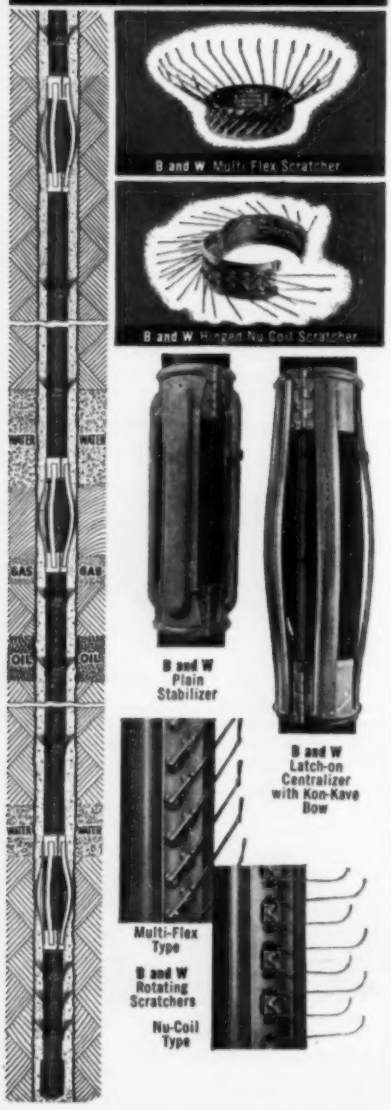

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TABLE 6. Resistivity of Water Samples, Rusk, Panola, and Shelby Counties, Texas.

Map Index	Field	Formation	Approximate depth, ft	Average resistivity R_w at 75 F, ohm-meter
		Rusk County		
1	East Texas	Woodbine	3600–3800	0.120
2	East Texas	Woodbine	3600–3800	.129
3	Henderson	Pettet	7260–7270	.048
3	Henderson	Travis Peak	7500–8000	.047
4	Gum Springs	Woodbine	3650–3715	.150
5	Big Barnett	Woodbine	3750–70	.138
6	Stegall	Woodbine	3760–3800	.121
7	Pleasant Grove Deep	Woodbine	3850–4000	.126
8	Pleasant Grove Shallow	Nacatoch	2970–3000	.148
9	Minden	Travis Peak	7460–75	.045
		Panola County		
1	Bethany-Panola	Goodland limestone	2400–2600	.137
		Shelby County		
1	Huxley	Nacatoch	1500	.175
1	Huxley	Bacon	5375–5410	.056
1	Huxley	Rodessa	5530–40	.049
2	East Shelbyville	Fredericksburg limestone	3600	.086

FIG. 9. **Source of water samples** collected in Rusk, Panola, and Shelby counties, Texas.

R_t = true resistivity of the formation, ohm-meters.

From the electric-induction log section in Fig. 3, the average values of true resistivity (R_t) for the two productive sands under investigation were determined from the reciprocated induction curve to be 6 ohm-meters for sand A and 11 ohm-meters for sand B. Average values of formation resistivity (R_o) for these two sands were calculated using the conductivity curve below the water-oil contact to be about 0.6 ohm-meter for sand A and 0.4 ohm-meter for sand B. (In this example it is assumed that both sands have the same physical characteristics above and below the water-oil contacts and that each sand below the oil-saturated zone represents the resistivity of that sand at 100-percent water saturation.) The formation-water resistivity (R_w) selected from Table 7 equals 0.085 ohm-meter at 75 F. Adjusting this value to a formation temperature of 132 F using curves in Fig. 2, R_w equals 0.048 ohm-meter. The formation resistivity factor (F), calculated from Equation 3, equals 12.5 for sand A and 8.3 for sand B. Finally, the water-saturation exponent (n) was assumed to equal 2.0.

Using Equation 4 and 5, porosity

TABLE 7. Resistivity of Water Samples, Anderson, Cherokee, and Houston Counties, Texas.

Map Index	Field	Formation	Approximate depth, ft	Average resistivity Rw at 75 F, ohm-meter
		Anderson County		
1	Cayuga	Woodbine	3800–4100	0.085
2	Blackfoot	Rodessa	8950–9000	048
3	Boggy Creek	Woodbine	3430–3600	074
4	Neches	Sub-Clarksville	4520–4670	071
4	Neches	Woodbine	4680–4750	070
5	Tennessee Colony	Rodessa (Lower)	8950–9050	049
6	Long Lake	Woodbine	5300–5400	073
7	East Long Lake	Woodbine	5350–5450	072
8	Camp Hill	Sub-Clarksville	5100–5200	081
9	West Slocum	Woodbine	5750–60	078
10	North Slocum	Sub-Clarksville	5710–20	083
11	South Slocum	Sub-Clarksville	5820–30	081
11	South Slocum	Woodbine	5930–50	074
		Cherokee County		
1	Larissa	Woodbine	5410–50	068
1	Larissa	Pettet[1]	10,160-10,210	052
2	North Jacksonville	Woodbine	4350–4450	087
3	Stone	Woodbine	3750–3800	116
4	Lone Star	Nacatoch	3300	136
4	Lone Star	Woodbine	3940–4060	077
5	West Jacksonville	Woodbine	4830–4960	075
6	Dottie Sue	Woodbine	5080–90	076
7	Rusk	Woodbine	5120–5200	072
8	Watson Wise	Woodbine	5080–5140	075
		Houston County		
1	Navarro Crossing	Woodbine	5700–5900	073
2	Grapeland	Sub-Clarksville	5870–5900	086
3	Grimes-Percilla	Woodbine	5880–5900	069

FIG. 10. **Source of water samples** collected in Anderson, Cherokee, and Houston counties, Texas.

and water saturation are estimated as:

Sand A.

$$\text{Porosity} = \sqrt[2.15]{\frac{0.62 \times 0.048}{0.6}} \times 100 = 24 \text{ percent; and}$$

$$\text{Water saturation} = \sqrt{\frac{0.048 \times 12.5}{6}} \times 100 = 32 \text{ percent.}$$

Sand B.

$$\text{Porosity} = \sqrt[2.15]{\frac{0.62 \times 0.048}{0.4}} \times 100 = 30 \text{ percent; and}$$

$$\text{Water saturation} = \sqrt{\frac{0.048 \times 8.3}{11}} \times 100 = 19 \text{ percent.}$$

Available core analyses from this formation show that the following average porosity values for the two sands are 27 percent for sand A and 29 percent for sand B. Laboratory-determined water saturations for these two sands were not available.

Index Maps and Tables

Maps of counties (Fig. 4 through 12) show the geographical locations of the oil fields from which water samples were obtained for this survey. Index numbers on the maps refer to the general location of the fields and not to the exact location within the fields where the samples were collected. Average resistivity for each productive formation corresponding to the index number is given in Table 1 through 9. These tables also give the name of the field, formation, subproducing zone (if known), and approximate depth to the formation from which water was sampled.

A simplified geologic column generally accepted in the Northeast Texas area is shown as Fig. 13.

Summary

The interpretation of electric logs may be considered a combination of a skill and a science that can be developed only with practice. Knowledge of formation characteristics and their effects on well logs are a great help, as assumptions are often necessary in the course of this work. The more information that is available reduces the number of assumptions and increases the range of reliable interpretations that can be made by the log analyst. It is toward this end that this report has been prepared to provide water-resistivity data essential in interpreting electric logs.

Resistivity of formation waters in Northeast Texas ranges from 0.044 to 0.551 ohm-meter at 75 F. Resistivity generally decreases with depth to the

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FIG. 11. **Source of water samples** collected in Navarro, Freestone, and Leon counties, Texas.

TABLE 8. Resistivity of Water Samples, Navarro, Freestone, and Leon Counties, Texas.

Map Index	Field	Formation	Approximate depth, ft	Average resistivity R_w at 75 F, ohm-meter
		Navarro County		
1	Rice	Nacatoch	590–640	0.216
2	Flag Lake	Woodbine	2700–3100	274
3	Corsicana	Wolfe City	980–1100	189
4	Mildred	Nacatoch	800–1000	339
5	Combest	Nacatoch	680–730	354
6	Bazette	Woodbine	2950–3280	327
7	Edens	Nacatoch	800–880	342
8	Powell	Nacatoch	980–1000	305
8	Powell	Wolfe City	1530–1630	191
8	Powell	Taylor Marl	1950–2050	184
8	Powell	Woodbine	2580–3000	430
9	South Kerens	Woodbine	3370–3410	227
10	Carter-Gragg	Pettet	6830–40	052
11	Richland	Woodbine	2930–3000	405
12	North Currie	Woodbine	3000	295
13	Currie	Woodbine	2900–3000	300
14	North Reiter	Nacatoch	700–750	325
		Freestone County		
1	Stewart Mills	Woodbine	4000	113
2	Cayuga	Woodbine	3800–4100	085
3	Reiter	Nacatoch	960–1030	337
4	Wortham	Woodbine	2950–3000	280
5	Long Lake	Woodbine	5350–5450	073
		Leon County		
1	Buffalo	Woodbine	5650–5750	095
2	Oakwood	Woodbine	5750	078
3	Navarro Crossing	Woodbine	5700–5900	073

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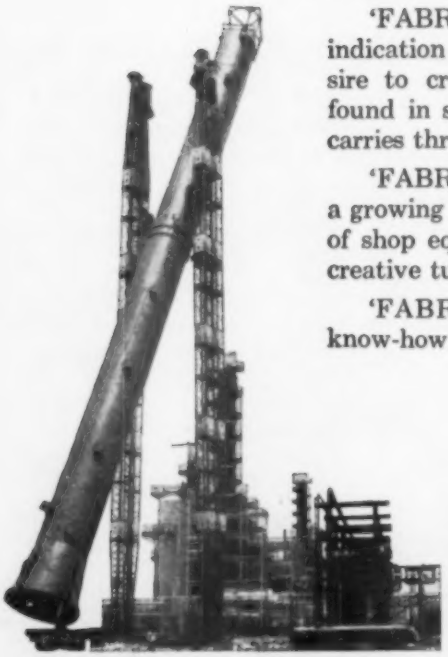

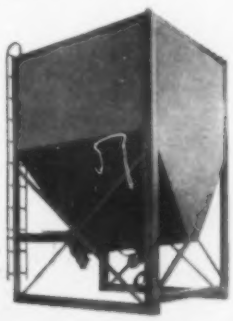

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TABLE 9. Resistivity of Water Samples, Limestone, Falls, and Robertson Counties, Texas.

Map Index	Field	Formation	Approximate depth, ft	Average resistivity R_w at 75 F, ohm-meter
		Limestone County		
1	Nigger Creek	Woodbine	2840–60	0.227
2	Mexia	Woodbine	3000–3100	.224
		Falls County		
1	Deer Creek	Buda limestone	1050–60	.338
2	Lott	Buda limestone	1210–50	.321
		Robertson County		
1	Calvert	Nacatoch (Gibson sand)	2130–2230	.227

formation, although direct correlation with depth is not apparent in any formation sampled. The lateral variation in resistivity of formation water is usually small within local area. Therefore, reasonably reliable resistivity for formation waters in fields and wildcat areas not included in the report can be estimated by interpolating the presented data for nearby fields.

Resistivities presented in this report were checked by correlation for possible errors, and doubtful values were omitted from the average resistivity shown for each formation water in the tables. These data should increase the accuracy and ease of quantitative analysis of electric logs from wells in Northeast Texas. Before these data are used, it should be remembered that the resistivities must be adjusted to the temperature of the formation under investigation.

FIG. 12. **Source of water samples** collected in Limestone, Falls, and Robertson counties, Texas.

SYS.	SERIES	GROUP	FORMATION	TYPICAL NAMES OF SUBPRODUCING FORMATIONS
TERTIARY	EOCENE	CLAIBORNE	CLAIBORNE	REKLAW SANDSTONE & CARRIZO SANDSTONE
		WILCOX	WILCOX	
		MIDWAY	MIDWAY	
CRETACEOUS	GULF	NAVARRO	ARKADELPHIA	
			NACATOCH	NACATOCH SANDSTONE, NAVARRO CHALK & GIBSON SANDSTONE
		TAYLOR	SARATOGA	
			MARLBROOK	
			ANNONA	ANNONA CHALK
			OZAN	BLOSSOM SANDSTONE, PECAN GAP & WOLFE CITY
		AUSTIN	BROWNSTOWN	
			TOKIO	TOKIO SANDSTONE
		EAGLE FORD	EAGLE FORD	SUB-CLARKSVILLE SANDSTONE, BLALOCK SANDSTONE, ORR SANDSTONE & COKER SANDSTONE
		WOODBINE	WOODBINE	LEWISVILLE SANDSTONE & DEXTER SANDSTONE
	COMANCHEAN	WASHITA	UNDIFFERENTIATED	BUDA LIMESTONE
		FREDERICKSBURG	UNDIFFERENTIATED	GOODLAND LIMESTONE
		TRINITY	PALUXY	PALUXY SANDSTONE
			MOORINGSPORT (UPPER GLEN ROSE)	
			FERRY LAKE ANHYDRITE (GLEN ROSE MASSIVE ANHYDRITE)	
			RODESSA (LOWER GLEN ROSE)	BACON LIMESTONE, HILL SANDSTONE, GLOYD LIMESTONE, HENDERSON SANDSTONE, ORR SANDSTONE & YOUNG LIMESTONE
			JAMES (LOWER GLEN ROSE)	JAMES LIMESTONE
			PINE ISLAND (LOWER GLEN ROSE)	
			PETTET (LOWER GLEN ROSE)	PETTET LIMESTONE, VENTERS SANDSTONE & PITTSBURG SANDSTONE
			TRAVIS PEAK	TRAVIS PEAK SANDSTONE, HURLEY-ORR SANDSTONE & ELLEDGE SANDSTONE
JURASSIC		JURASSIC	COTTON VALLEY	
			BUCKNER	
			SMACKOVER	SMACKOVER LIMESTONE

FIG. 13. **Generalized geological column** of Northeast Texas.

Acknowledgments

The writer gratefully acknowledges the cooperation and assistance of the officials and employees of the 88 oil companies that made this report possible by supplying water samples and water analysis data.

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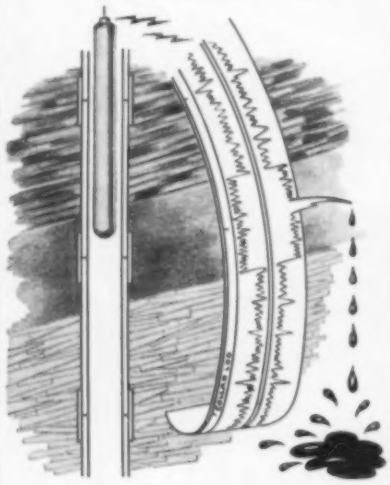

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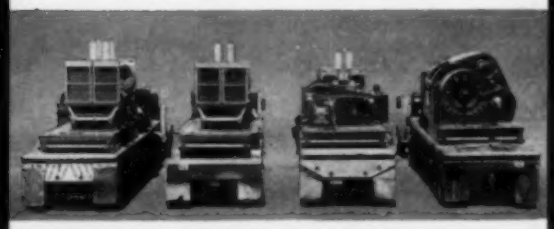

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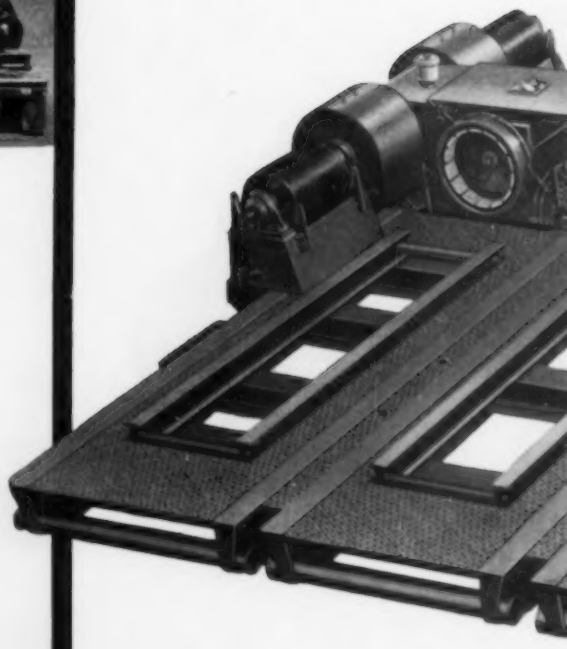

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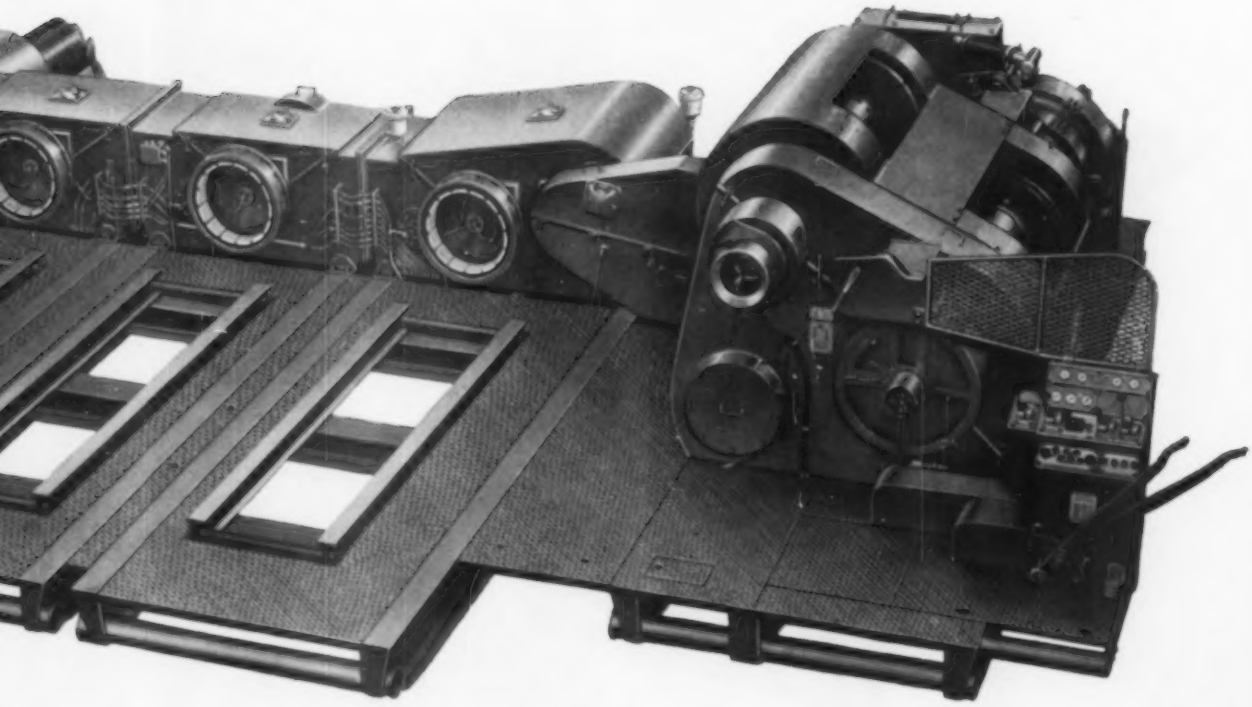

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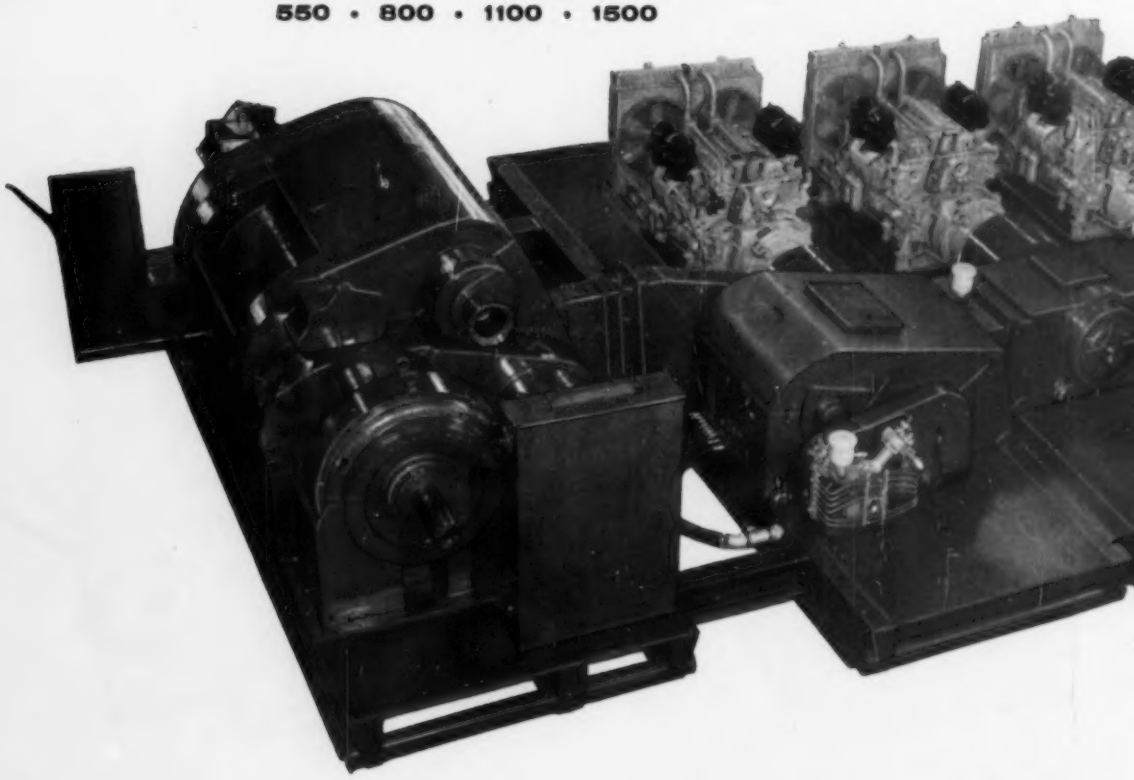

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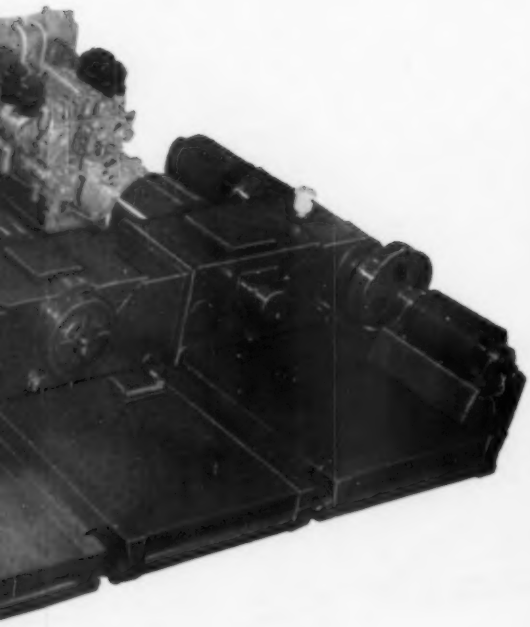

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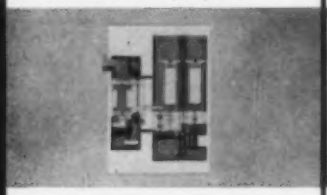

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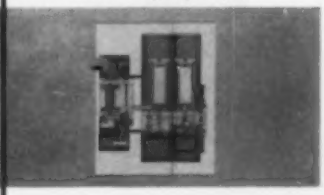

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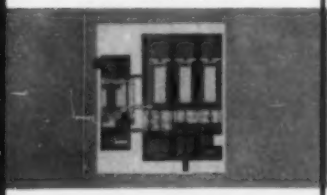
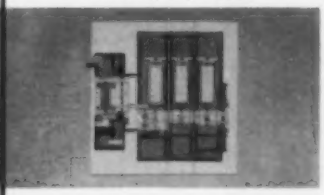
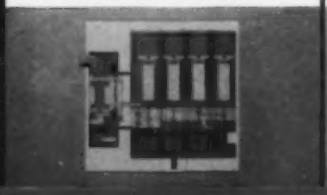


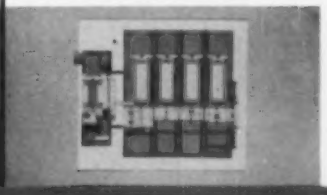
Three-engine power end with rear pump drives



Four-engine power end with two side pump drives



Four-engine power end with rear pump drives



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You'll find it's the most completely stocked supply store you've seen . . you'll enjoy browsing around. There's always a comfortable chair for you and all the latest bulletins for a look at what's going on in new and used equipment. Any time you drive by . . drop in for a chat and visit. You'll find a ready welcome at your Continental-Emsco Store.

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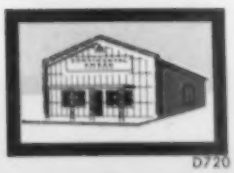

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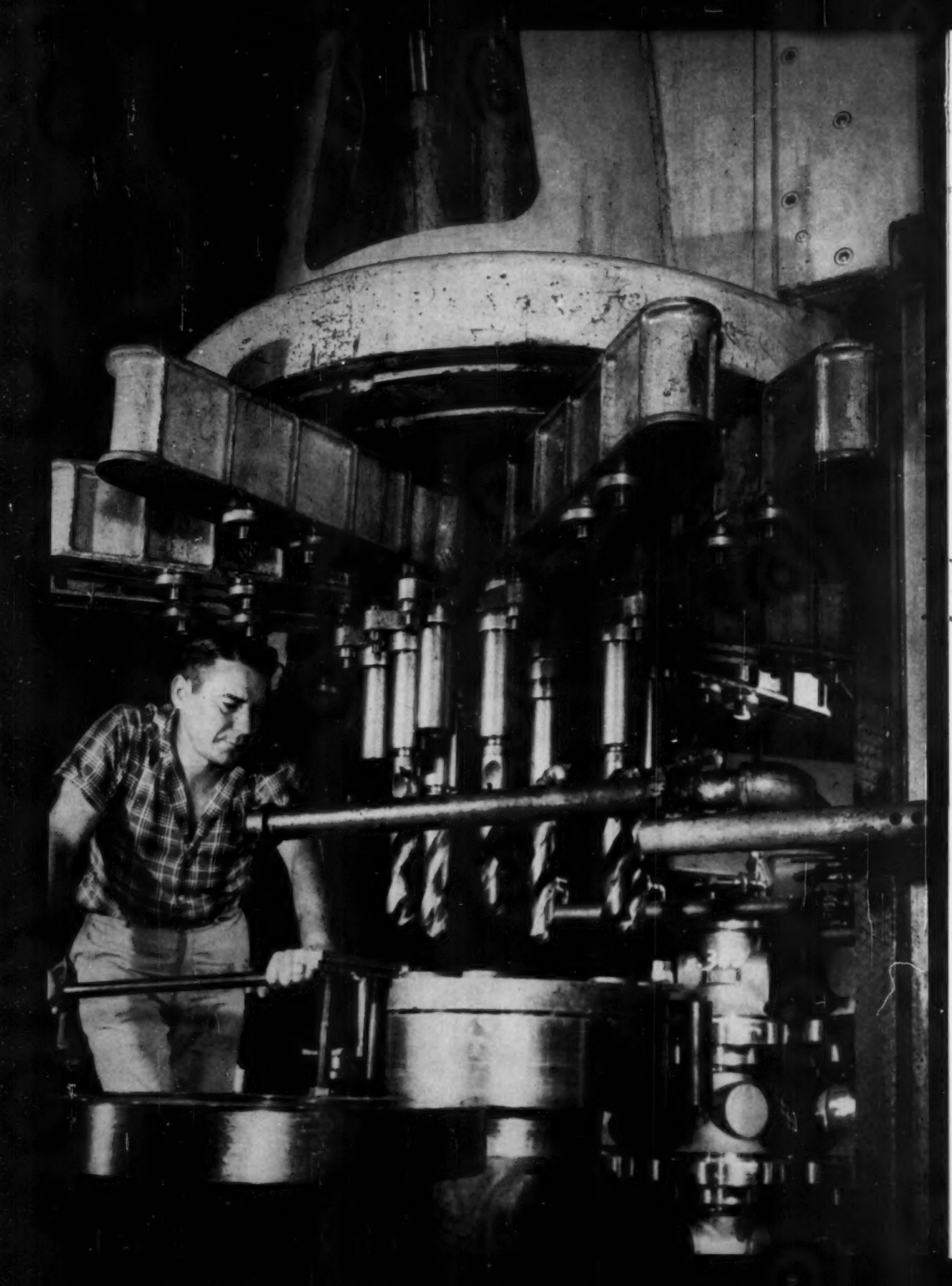

Famous Wildcatter

The man at the machine is a craftsman.

And why shouldn't he be called a wildcatter?

His "drilling" equipment in this instance consists of a huge drill press boring machine and he's digging through metal rather than the Devonian.

But, the machinist puts skill and imagination into machines like this and works unexplored areas to turn out new products that will help the oil industry produce petroleum more efficiently, more economically.

Sure, he's a wildcatter!

And, he's typical of the craftsmen associated with the Oil Center Tool Company — expert machinists who pride themselves on their ability to produce the best, the latest in oilfield equipment at the precise moment of need.

The oil industry isn't composed just of the geologist with the map, the man at the drilling controls, the integrated companies, the shoestring operators, the twinkling of derrick lights in the night, the screaming protests of drillpipe being coupled, the white smoke signals from a steam rig.

The oil industry is much more than this.

The Oil Center Tool Company machinist is a vital part of the industry, too.

For, of what avail would the designs of the scientists be if there were not craftsmen to transform the blueprints into usable products?

But, a man is a wildcatter for reasons other than just a situation.

Sometimes destiny (or a well-executed idea backed up by lots of hard work and determination to excel) plucks a company out of the crowd. It becomes known for succeeding where others overlooked an opportunity.

To be a wildcatter, a man has to have a certain spirit.

That spirit defies precise definition.

Generally, however, it involves a desire to "be first."

That is what makes O-C-T craftsmen stand out—they have knowledge and equipment; but, coupled with that is a realization of the responsibility that is theirs and a resulting determination to be first with the best.

An O-C-T Christmas Tree doesn't stand hollowly alone.

There are many things in it.

Like the craftsmanship of O-C-T machinists, for example.

That's the strongest support you can have . . . for a Christmas tree or anything else.

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Export Representatives: South America — East West Oiltools, C. A., Del Lago Hotel, Maracaibo, Venezuela. Address Export Inquiries for All Other Countries to P. O. Box 3091, Houston, Texas.

This O-C-T machinist is operating a radial drill press, one of a number of new types of equipment the company employs in its Houston plant. O-C-T machinists are craftsmen and they are a basic part of the company's strength.

A contractor and an operator view...

Drilling Costs In California

... and both agree: "The drilling picture is getting a pretty expensive frame"

Part I

Contractors to Cut Costs Closer

R. C. Sharp
Kellogg Overseas Corporation, Compton, California

DURING the years from 1947 to 1956 the contractors' daily operating costs in California have increased 42 percent. In this same period the rate of penetration has increased 48 percent, resulting in an actual reduction of 16 percent in footage prices.

Viewing the future of drilling in California, it will be necessary that there be closer cooperation and understanding between operators and contractors with the end in view of continuing to reduce drilling costs even in the face of increasing daily costs.

It is doubted that there is a contractor in the country who would not welcome the opportunity of a captive audience of oil men in order to talk about drilling costs. We are not noted for our forensic ability, but we do love to talk about costs. It is rather like asking an elderly maiden lady to talk about her recent operation. We live with costs every hour of the day and each time we are asked to submit a bid (which has not been too frequent of late) we go over and over our costs to see where we can cut a dollar here or a dollar there. Yes, and like the lady with the operation, we can even show you some very interesting scars.

Our constant concern with costs is, of course, due to the very competitive

"Drilling Costs in California" was presented as a paper at the spring meeting of the Pacific Coast district, Division of Production, American Petroleum Institute, Los Angeles, California, May 16 and 17, 1957.

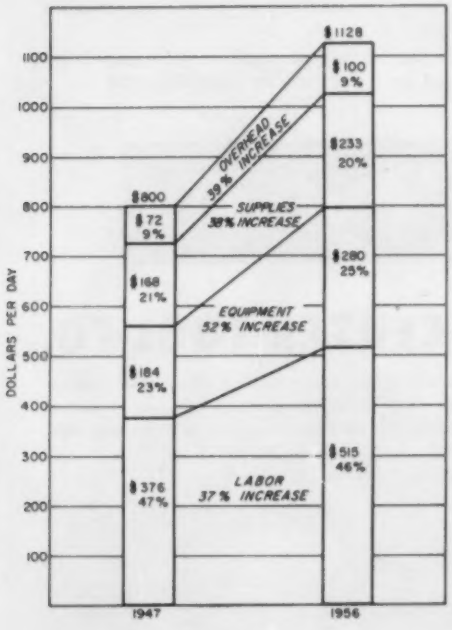

FIG. 1. **Operating costs per day** as incurred by a drilling contractor on a 10,000 ft California rig. Chart is set up on a daywork basis.

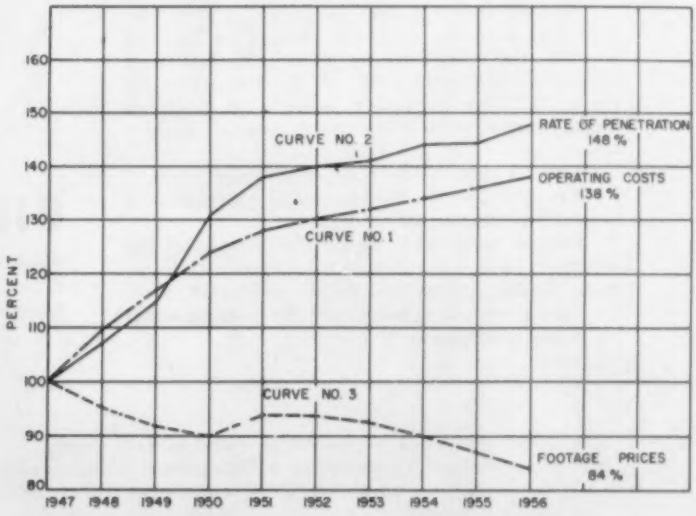

FIG. 2. **Drilling costs** in California follow two distinct trends. Costs and penetration rates show a steady incline as footage prices continue downward.

The "Cone Nebula" in the constellation of Monocerus photographed through the 200-inch Hale telescope of the Palomar Observatory. This mass of stars is about 1,000 light-years, or roughly six million billion miles from the earth.

MEASURING THE UNSEEN

Although attempting nothing so spectacular as measuring unseen stars through a 200-inch telescope, Tuboscope research is paying off for oil men everywhere. From Tuboscope research have come new instruments for measuring the nearly unseen effects of wear, fatigue, and corrosion in oilfield tubular goods. And from Tuboscope experience in the field comes the ability to inspect and to grade your tubular goods with the greatest possible precision and with the least chance for human error. The important factors of bottom hole pressure and temperature are measured by Tuboscope's Subsurface Engineering Division.

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NEW SERVICES . . . such as the "Mr. George" giant offshore delivery vessel now serving offshore Louisiana Gulf Coast rigs. Carries up to 1500 tons of mud materials per load.

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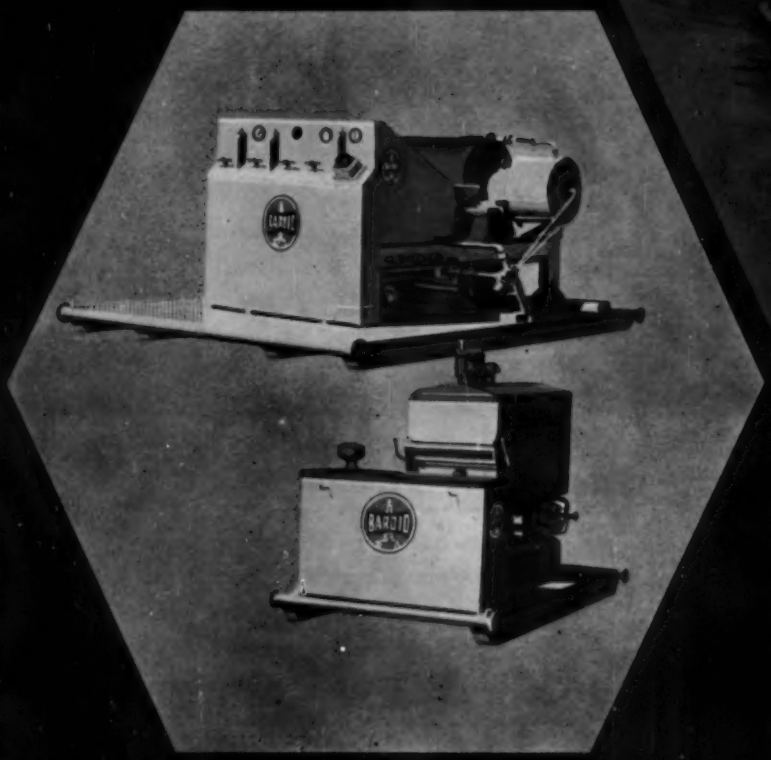
NEW PLANTS . . . such as the new Marine Terminal and mill at New Orleans. Baroid has increased its stockpiles of products at all important points.



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continues to set the pace for mud service!

NEW PRODUCTS . . . nearly a dozen new, field-proved mud products for fast, economical drilling. New lost circulation materials, surfactants, emulsifiers, thinners, anti-contaminants . . . each a champion in its class.

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This year, as your drilling activity speeds up, you will find Baroid already prepared to meet your increased mud needs. Baroid foresaw your requirements and *now has in service* new plants, new products, new equipment and new services.

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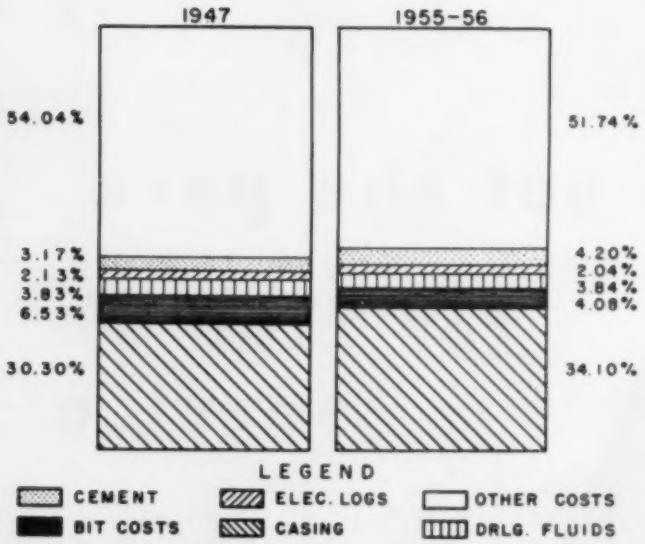


FIG. 3. **Percentage comparisons** of mud, bits, casing, cement and electrical logging services point to two significant changes in the past 10 years. Casing costs have gone up and bit costs down; other costs have remained almost static.

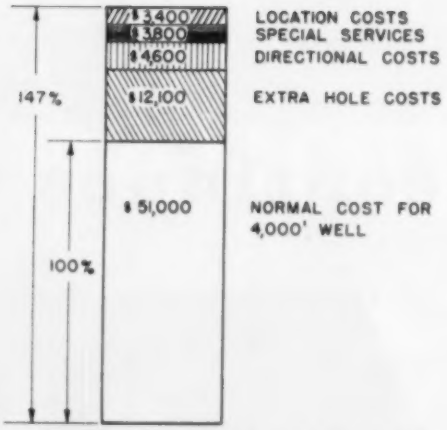


FIG. 4. **Costs of drilling on restricted residential drillsites** is high. The "normal cost" of $51,000 shown here represents drilling to a 4000 ft vertical depth at an average drift angle of 45 deg after normal build-up. Total depth of the well is 5300 ft and requires 25 days to drill.

nature of our business. We have found that without this concern we cannot survive. Few of us have been trained as economists but if we have been around very long we have learned that the economics of contract drilling is number one on our list. The basic problem during the past 10 years has *been* economic — how to continue to reduce the costs of drilling a foot of hole in the face of increasing costs of equipment and labor and supplies. Take a look at the record of the past 10 years and then consider what is likely to happen in the future.

First, it might be well to consider a few basic facts. Costs are the number one problem. **As applied to California, if the overall cost of finding and producing a barrel of oil in this state becomes too far out of line with these same costs in Texas, Oklahoma, or even in the Middle East, then no producing company can or will produce the California oil.**

It follows then that all of us in the producing end of the oil industry in California must be concerned with costs if we are to survive, and this is true whether we are producers, supply people, or contractors. If you doubt that drilling costs are of paramount importance, consider that out of a total of 265 drilling rigs in the state only 164 or 62 percent are currently operating.

A Significant Contribution

The drilling contractor's contribution to these problems can be significant since they drill approximately 93 percent of all wells drilled in the United States. The exact figure for California is not available, but it is only slightly less than this national average. There are some interesting comparisons between California drilling operations as compared to the national totals; some of them a little hard on the ego of a native son. In 1956, 58,300 wells were drilled in the United States; 2374 of these were drilled in California, or approximately 4 percent. The total footage drilled was 234,000,000 nationally, as compared to 11,000,000 in California, or approximately 5 percent. This larger percentage of total footage is due to the fact that the average depth of the California wells was 4750 ft against a national average of 4020 ft. The fact that the California wells averaged 18 percent greater depth partially explains the fact that our average penetration per day was somewhat below the average for the entire country.

Many other factors such as more difficult formations, more directional drilling, and longer completion work, all combine to explain why the average footage drilled per operating day in California in 1956 was 166 ft while the average for all United States wells was 226 ft per day. One further comparison of interest is the fact that in 1956 out of a total average of 2846 rigs running in the country, 187 or 6.6 percent of these were operating in California. Contributions which the California drilling industry has made to the progress of the

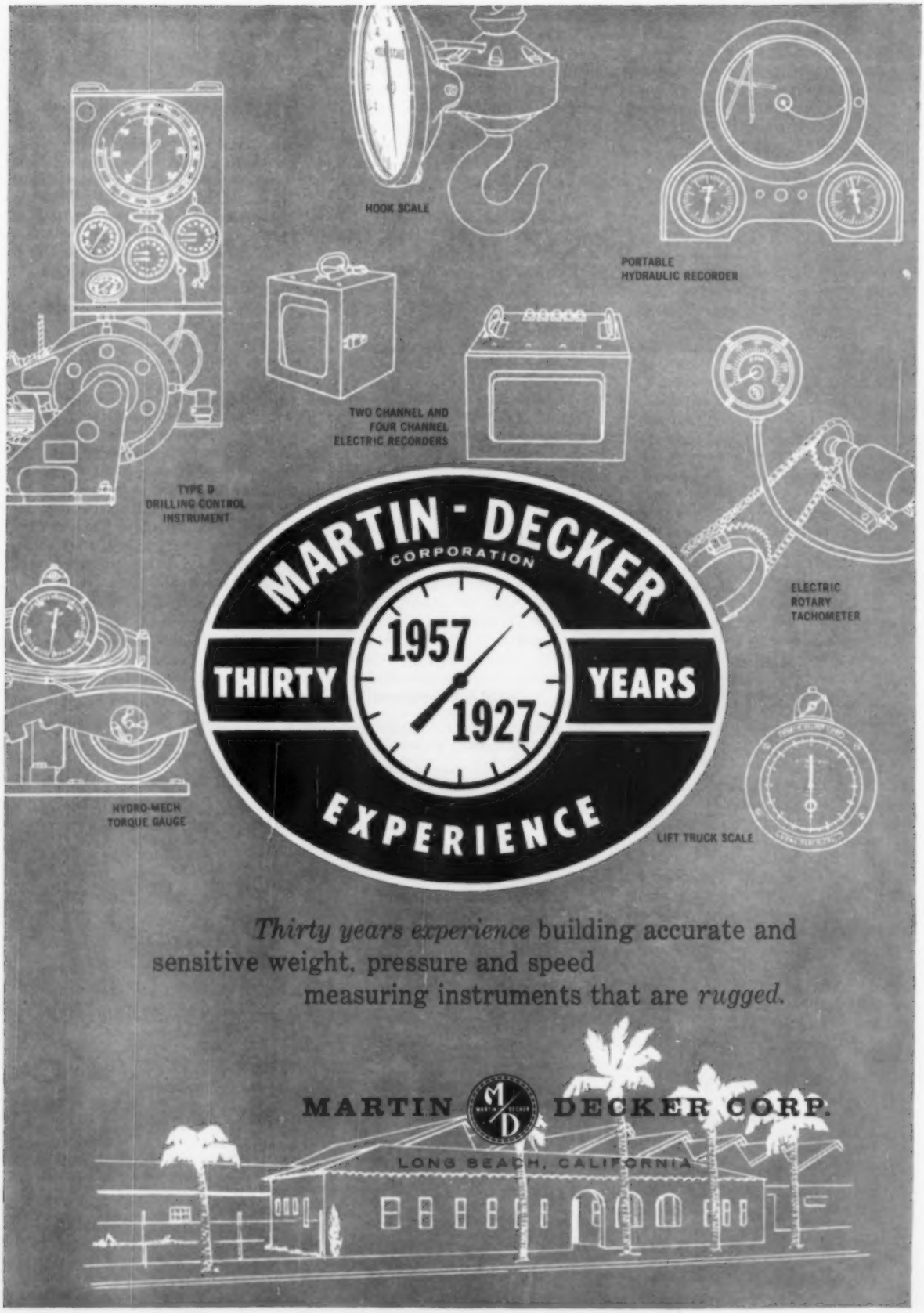
TABLE 1.

10 Year Comparison
Depth Range 4000-6000 ft

Item	Year	No. Wells	Total Well Costs		Item Cost	Percent Of Total
Mud	1947	17	$ 631,714		$ 24,211	3.83
	1955-56	33	$1,693,590		$ 58,223	3.84
Bits	1947	17	$ 631,714		$ 41,189	6.53
	1955-56	11	$ 516,178		$ 21,045	4.08
Casing	1947	32	$1,693,714		$513,608	30.3
Cement	1955-56	15	$ 948,974	Casing	$323,292	34.1
E-logs						
				Cement	$ 53,678	3.17
					$ 39,826	
				E-logs	$ 36,166	2.13
					$ 19,329	2.04

Depth Comparison
Year 1955-56

Item	Depth	No. Wells	Total Well Costs	Item Cost	Percent Of Total
Mud	4000'- 6000'	33	$1,693,590	$ 58,223	3.84
	7000'-10,000'	35	$4,500,660	$221,153	4.91
Bits	4000'- 6000'	11	$ 516,178	$ 21,045	4.08
	7000'-10,000'	3	$ 291,968	$ 29,825	10.2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PORTABLE HYDRAULIC RECORDER
TWO CHANNEL AND FOUR CHANNEL ELECTRIC RECORDERS
TYPE D DRILLING CONTROL INSTRUMENT
MARTIN-DECKER CORPORATION
1957
THIRTY YEARS
1927
EXPERIENCE
ELECTRIC ROTARY TACHOMETER
HYDRO-MECH TORQUE GAUGE
LIFT TRUCK SCALE
Thirty years experience building accurate and sensitive weight, pressure and speed measuring instruments that are rugged.
MARTIN DECKER CORP.
LONG BEACH, CALIFORNIA

industry as a whole is way out of proportion to the percentages given above. For the very reason there have been difficult and unusual drilling problems, so the "Prunepickers" have come up with new methods and new equipment that have proved beneficial to all drilling throughout the world.

Facts and Figures

When taking a closer look at what has happened to the cost of operating a California drilling rig in the last 10 years it is of necessity that a rig of one size be used for comparative purposes because of the great variation in costs between the lightest rigs of 2500-ft rating and a heavy rig capable of drilling to 25,000 ft. For this purpose, a usual California 10,000-ft rig, equipped with a mast, complete hydraulic blowout equipment, 12,000 ft of drill pipe, and two sizes of drill collars is used. Because certain costs, such as moving expense, fuel, mud, and bits vary so widely from well to well, it is also assumed a daywork job where such costs are paid by the operator.

Fig. 1 graphically illustrates the change in operating costs per day from 1947 to 1956. Labor includes all labor except office help and management. The equipment classification includes all capital items, such as the rig itself, the drill string, mast, and all accessory equipment. This is the item which some contractors, in periods of low rig activity and low prices frequently fail to include as a just cost. By so doing, they are only working on "borrowed time" or perhaps more accurately on "borrowed money." The item of supplies includes everything purchased and "used up" by the contractors — wire lines, pump parts, lubricants, and repairs to the equipment. The final classification of overhead includes all office expense, legal fees, and management costs. It also includes a small allocation of dollars and time spent in AAODC activities, in an effort to improve service to the oil industry. In recent years activities have been expanded in the AAODC as the research program, safety work, and public relations.

It is also interesting to note that although the daily cost of operating a 10,000-ft rig has increased to 142 percent in 10 years, the ratio of increase in each of the four items has remained constant. Also, in comparing these figures for California with the data for all wells drilled in the country, the ratio of increase has been very similar, California showing an overall increase to 142 percent in 10 years and the national average increasing to approximately 138 percent. It is doubtful that the contractor, any contractor, can do anything about existing costs. If he pays adequate wages, has good equipment and keeps it in shape, it is going to cost about $1128 per day to operate this type of rig. Perhaps an individual contractor can lower his depreciation or maintenance charges for a period of time, or perhaps he can forget the inherent hazards in footage contracts, but if he does it for long he will end up with a yard full of obsolete iron and an office full of creditors.

One of the best formal studies of the industry was made by Dr. Hodges and Dr. Cookenboo, published in 1952 by the Rice Institute, in a pamphlet titled "The Oil-Well Drilling Contractor Industry; a Case Study in Pure Competition." The authors make this comment, "The historical trend of the drilling contractors' industry has been cyclic in character — a cycle begins with a period of acquisitions and progresses and ends with a period of liquidation and stagnation." In plain English this quotation means that the contractors have their ups and downs; the up begins with the purchase of a rig — often too many rigs — the down begins with going broke, a sheriff's sale, and back to roughnecking. It is exactly this sort of cycle that contractors are hoping to change by a sound program of education of the entire oil industry, and particularly through education of the contracting group.

It may be noted in Fig. 1 that California rig operating costs have increased to 142 percent from 1947 to 1956. Now look at what has happened to the cost of drilling a foot of hole — and here contractors have a good reason to be "chesty." Fig. 2 gives the 10-year trend of operating costs, rate of penetration, and footage prices. The data are based upon national totals; California costs closely follow the national trends. Using the year 1947 as the base, Fig. 2 shows that operating costs have increased to 138 percent in 10 years. During this same period, however, the rate of penetration has increased even more to a percentage of 148 percent as shown on curve 2, (Fig. 2). The contractor's job is to make hole and in 1956 he made 48 percent more hole per day than in 1947. This increased efficiency in the face of rising costs has resulted in curve 3 which shows that the cost per foot of hole has decreased to 34 percent in 10 years. To express it another way, the contractor is selling his product, a foot of hole, for 84 percent while at the same time his costs of producing that product have gone up to 138 percent. The answer is, of course, that he has produced more efficiently. All contractors are proud of this record and all contractors realize that they must share the laurels with the drilling equipment manufacturers

TABLE 3. Additional Well Costs Due to Residential Drillsite.

Cost of 4000 ft straight hole (normal conditions)			$ 51,000
Extra costs due to residential location*			
Extra Hole Costs	1. Drilling time for additional 1300′ Est. 250/day @ 5½ days	@ $950/day	$ 4,940
	2. Extra casing required 1300′ of 8⅝″, 32#	@ $3.53/ft	4,600
	1300′ of 2½″, 6.5#	@ $0.97/ft	1,260
	3. Extra bits — Est. 3	@ $260 ea	780
	4. Daily mud costs	@ $100/day	520
		Sub-Total	$ 12,100
Directional Costs	1. Required Whipstocks — Est. 3	@ $525	$ 1,575
	2. Rental of directional control equipment		390
	3. Rental of Non-magnetic drill collars		1,135
	4. Reamer cutters — Est. 6 sets	@ $250/set	1,500
		Sub-Total	$ 4,600
Special Costs	1. Soundproofing (Installation prorated for 10 wells + $40/day rental)		$ 1,800
	2. Waste Disposal	@ $80/day	2,000
		Sub-Total	$ 3,800
Location Costs	1. Location (Includes special cellar, underground pipelines, fencing, etc.) per well		$ 2,500
	2. Special Underground wellhead equipment (over normal costs)		400
	3. Landscaping after drilling operations (average per well)		500
		Sub-Total	$ 3,400
		Total extra costs	$ 23,935
		Total cost of well	$ 74,935
		Percent of normal cost	147%

*All costs based on: 4000′ V.D.
45° Drift Angle
5300′ Total Depth
25 Days drilling and completion time

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for getting away from this trouble has always been to make use of the best available materials — *Natural Rubber* for the key material in plunger rings; *Synthetic Rubber* for the key material in resilient ball guides for cages.

The accurately grooved and drilled metal body of **The Martin Plunger** does not touch the barrel. Only the resilient rubber and duck rings contact the barrel. This material — with its great natural resistance to abrasion as well as its slipperyness-when-wet — has a much slower wearing action on the barrel. Most often your barrel will not need replacing. These rings have an amazing ability to take the kind of abuse that goes with oil well pumping, and this means longer runs. Plunger cost is reduced because replacing the rings costs only about one fourth as much as a new plunger, and this saving is, of course, added to the barrel saving and longer runs.

Patent No. 2,591,174

The Martin Rubber Guide Cage protects the ball from all metal contact except when it rests upon its seat. The ball is protected to such an extent that ball and seat life is usually doubled. The synthetic ball guide and stop cannot beat out because of its resilience. Its life is therefore much greater than any metal and you get this longer cage life in addition to better ball and seat life. The two guides are easily replaced when the occasion does arise.

No real capital outlay is required to get these benefits because the cost of Martin Plungers and Martin Cages is very much the same as you are now spending for replacements — sometimes less.

All regular or stroke-thru ROD PUMPS and TUBING PUMPS can be equipped with Martin Plungers. Martin Rubber Guide Cages are made in all sizes and styles. Write for our catalog No. 4; also see Composite catalog for 1956-57.

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who have made better tools with which to work. Improved and larger pumps, jet bits, engineered drilling strings, and a host of other improvements have made it possible to make more hole and charge less for this hole.

Finally, recognizing the importance of drilling costs and seeing what has happened to such costs in the last 10 years, what of the future in California? As in the past, drilling problems in this state are going to be difficult and will require imagination and creative thinking. Contractors are faced with deeper drilling, the many problems of drilling in residential areas, and perhaps most important from the standpoint of potential reserves, the problem of offshore drilling in deep water. When problems are added, costs are added, and here a very sincere plea is made for closer cooperation between operator and contractor in order to keep these costs as low as possible.

All too often the operator thinks only in terms of the lowest bid prices with no regard for quality of equipment, ability of drilling crews, or stability and reputation of the contracting company.

By the same token, the contractors all too often are unrealistic in their bidding and *encourage* this cutrate attitude of the operators. Mutual problems can best be solved by better understanding and better interchange of ideas. The drilling contractor is a specialist and should be consulted during the planning stages of any drilling program. The problems of hole deviation, the mud programs, and the type of equipment required, are all problems where the experience of the contractor is needed and should be used. His ideas could well lead to a reduction in drilling costs. The contractor should, in turn, present his ideas of the value of a standardized drilling contract, the reduction in costs when allowed to operate on a continuous drilling program, and the ever-present problem of keeping competent drilling crews together. This adds up to one thing — improved relations between operator and contractor. The AAODC has sponsored several panel discussions between operator and contractor and these have been stimulating and helpful. It is suggested that a regular group with a regular meeting date pursue this kind of discussion further. Operators and producers *are* on the same side of the fence and have the common goal of lower drilling costs for California. Let's work at it!

July 15th . . .

Equipment Reference Issue

Don't miss it!

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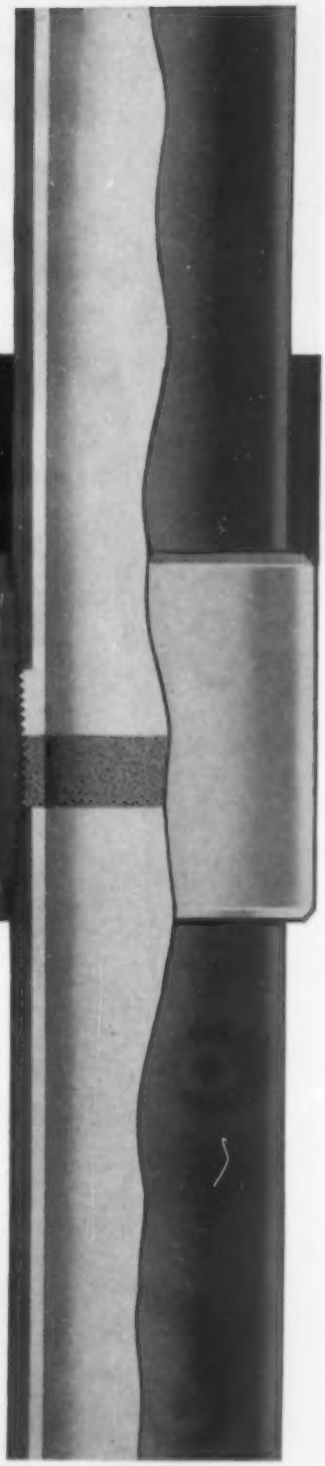
CEMENT LINED AT THE MILL



You find no ordinary cement in J&L Cement Lined steel pipe. Applied at the mill, this lining is a greatly improved product of continuing laboratory studies and grueling tests.

You get a tight bond between lining and pipe — an integral whole.

You get a satin-smooth interior with greater carrying capacity than steel pipe of the same I.D.

For a minimum investment you get complete protection against corrosion, tuberculation, iron contamination.

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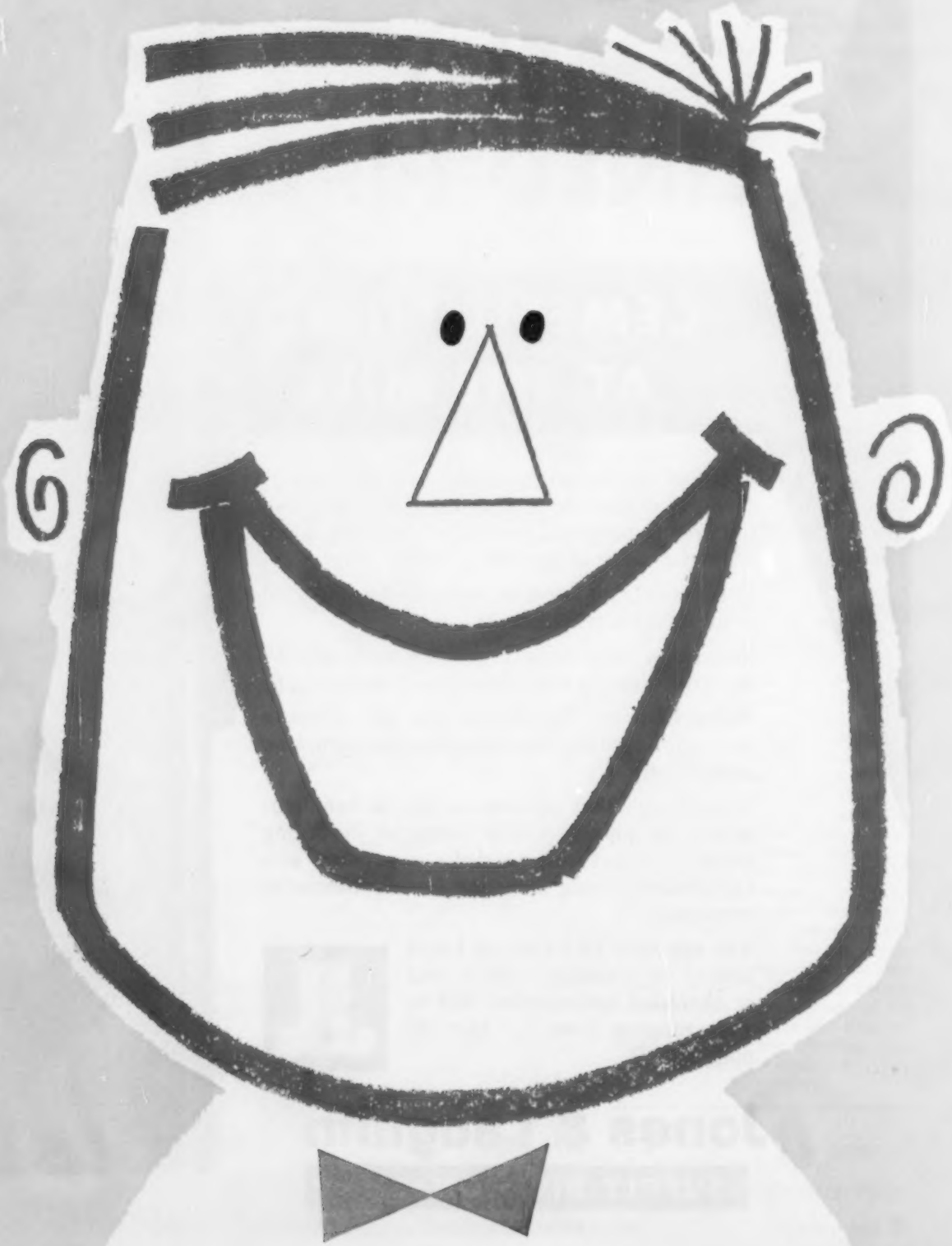

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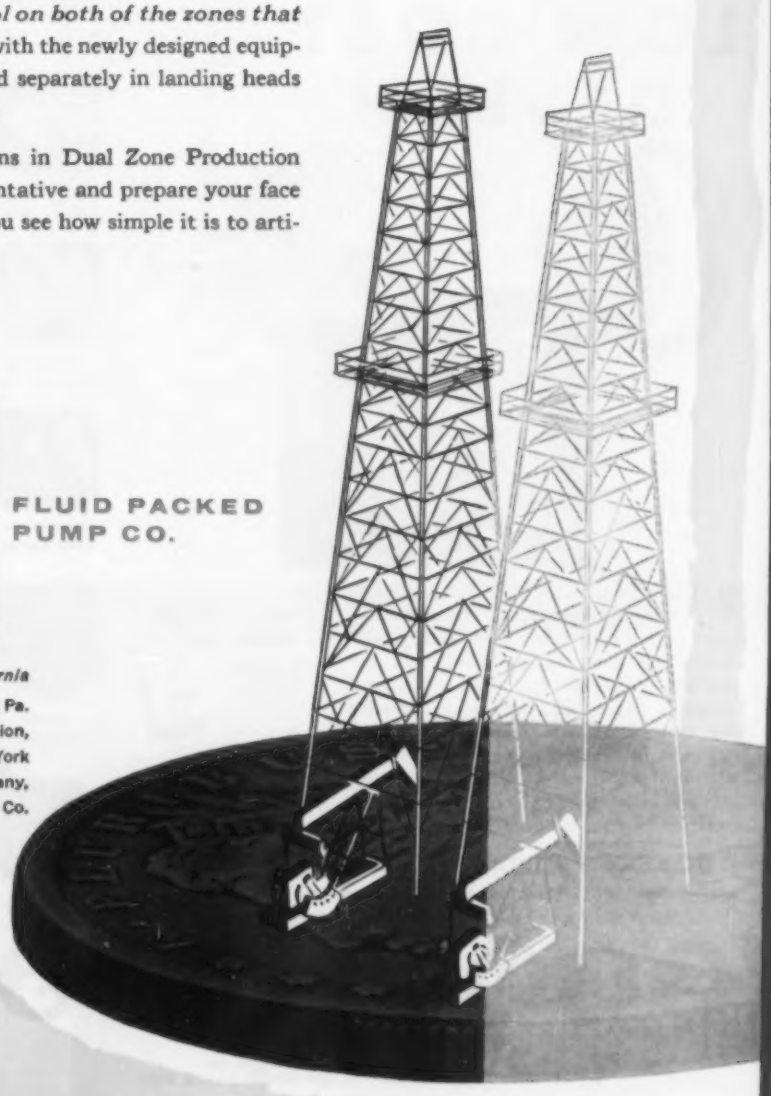

Part 2

Operators Foresee Added Costs

John J. LaBouff
Signal Oil and Gas Company, Los Angeles, California

A RECENT publication of the American Petroleum Institute[1] listed a collection of cost data which indicated that drilling costs, per foot, in California were higher than those of every other state save one. These data showed that drilling costs in California were nearly five dollars more per foot than those of the Rocky Mountain district, and over six dollars more per foot than those in the Mid-Continent. The normal reactions of California operators were lifted eyebrows and loud "how comes?".

The first portion of this paper, presenting the contractor's considerations of the cost problem, has already given some of the answers to "how comes?". Higher wage scales, cost of materials and various governmental regulations take their toll in dollars. This presentation of the operator's viewpoint of the cost problem will also try to answer some of the "how comes."

For the most part, this paper will ignore the dollars and cents aspects of the cost problem because everyone concerned certainly knows how much a string of 7-in. casing or a sack of quebracho costs these days. Actually, this whole subject falls more readily in the realm of the economist since a careful look at the overall price structure shows the inflated value of the dollar to be primarily responsible for what the industry has chosen to call "increased drilling costs." Recent articles in two of the oil magazines[2,3] showed that, by applying the 1950 dollar value to present costs, we are actually drilling some wells at a lower cost now.

Some Answers to "How Come?"

The figures mentioned previously, showing drilling costs to be higher in California than in other parts of the country, are honest and factual, but they do not tell the whole story. A little digging behind the scenes and reading between the lines produces the following reasons why the footage cost is lower in other areas:

1. In the Mid-Continent area alone nearly 10 times as many wells were drilled as in California and many of these were low cost shallow producers and service wells.
2. There is more widespread use of low cost cable tool methods in some areas.
3. Special completion fluids are not required in many hardrock areas.
4. Considerable savings have been realized by drilling rate and bit-life advantages of air drilling in some regions.
5. Research on new tools has been aimed primarily at Mid-Continent performance; examples, jet bits, chert bits, and turbodrills.
6. The Mid-Continent area has lower percentage of completed wells with the resulting savings in casing and rigtime. (The data showing California's drilling costs to be higher also showed a 73 percent completion record for California as compared to 65 percent for the Mid-Continent.)

When these considerations are joined with those presented in the first portion of this paper it is not difficult to see

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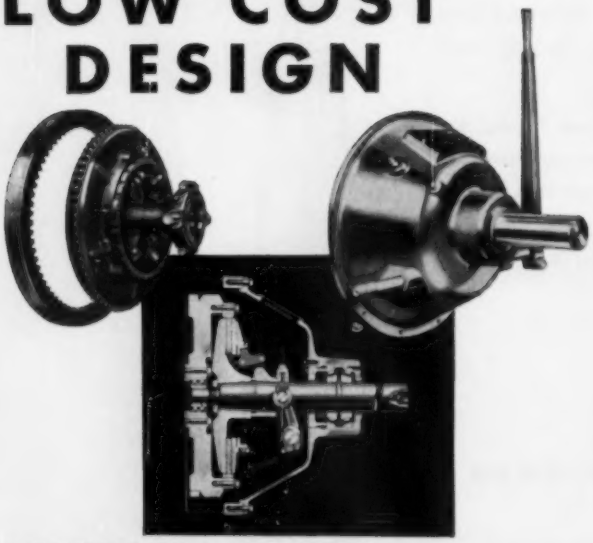

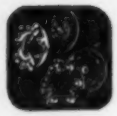
Small Spring Loaded

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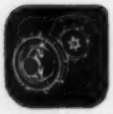
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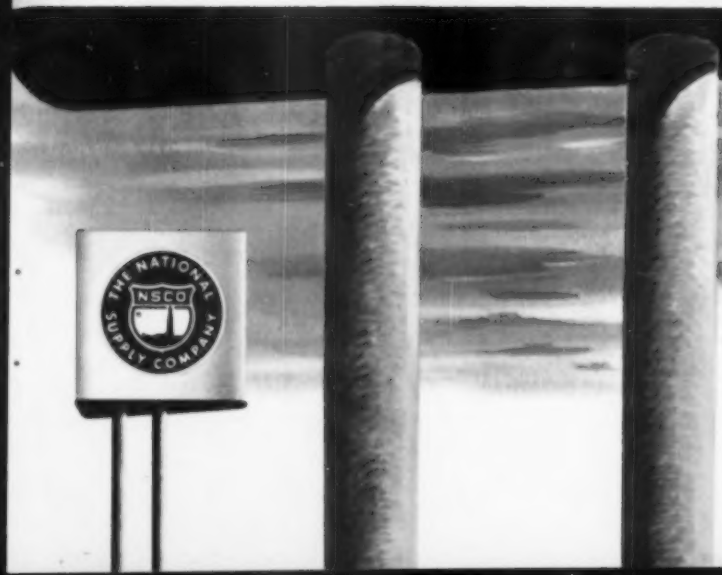

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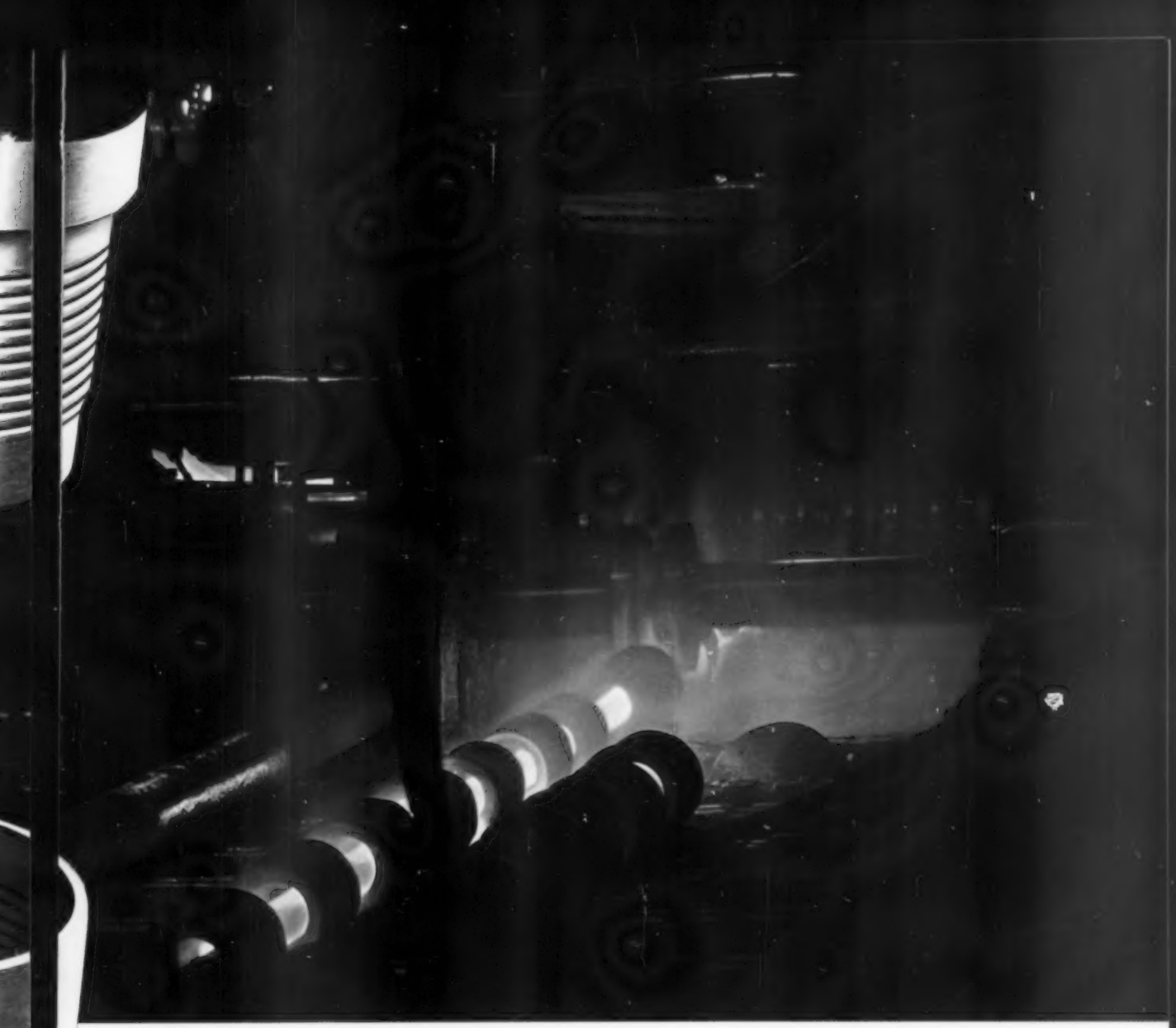

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why the average foot of hole drilled in Texas or Oklahoma is cheaper than the same foot drilled in California.

Well Costs in Past 10 Years

To make any significant comparison of well costs, it is necessary to use some parameter other than the dollar because of its ever changing value. A percentage comparison between wells drilled 10 years ago and those just recently completed should indicate whether or not present drilling costs are out of line. By comparing the cost of such items as casing, mud, bits, cement, and electrical logs to the total cost of wells drilled in 1947 and in 1955-56, it should be possible to determine where large increases in unit costs, if any, have occurred. These factors were chosen for comparison because they are a part of the cost of every development well drilled. Other important charges such as coring, perforating, and formation testing have not been considered because of their varying degree of usage.

Reliable data of this nature are understandably difficult to obtain because of various company policies and accounting methods, and the data presented herein are admittedly limited in scope. They are a compilation of records made available by several of the operators in this state, most of whom found it quite difficult to provide sufficient data for wells drilled in 1947.

Even so, the data available show a fair picture of the past 10 years and a glimpse of what is to come. Table 1 shows the comparison, percentagewise, of the costs of mud, bits, casing, cement, and electrical logging services for the 1947 and 1955-56 periods. It should be noted that there has been very little change for any of the items considered; practically none for e-logs and mud. The only changes of any consequence are for bits and casing. The reduction in the percentage cost for bits may possibly be explained by better mud programs and increased bit efficiency through better design. The cost of tubular goods amounts to nearly one-third of the total cost of a well. Increases in steel prices has a noticeable effect on the percentage cost for these items. Fig. 3 depicts the above comparisons graphically.

Since the figures of Table 1 show little percentage change in the amounts spent for the usual items required in drilling and completing wells, it can be assumed that the same is true for other tools and services, where applicable. That is, percentage costs of gun perforating today will be approximately the same as those of 1947 for perforated intervals of comparable length. There has been, however, a trend toward perforating much longer intervals during the past few years resulting in an increase in the cost of this type comple-

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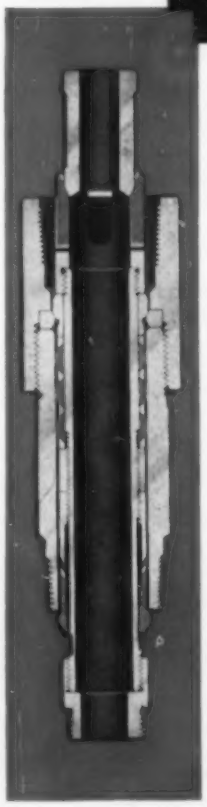

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tion. In a similar vein, there have been other changes in drilling and completion programs over the past few years. Some operators have made considerable reductions in the amount of coring done in both development and exploratory wells. They have relied, instead, on ditch samplings and formation tests to evaluate possible pays. Such programs have made significant savings in rig-time costs.

An important change noted in Table 1 is the increase in the percentage costs of mud and bits for wells in the 7000 to 10,000-ft class. There is nothing new or startling in the fact that drilling costs increase exponentially with depth, as indicated in Table 1. The point is that in California new production must, in part, come from deeper horizons not yet explored. As a result we are going to be faced with larger and larger per-well expenditures from our exploration and development budgets.

TABLE 2. Unit Cost Increases Since 1947.

	1947	1956	Percent of 1947 Cost
Average well costs (4000-6000 ft range).....	$37,200	$51,400	138%
Average tubular goods costs,$/ft....	$ 0.075	$ 0.12	160%
Average cost of bbl of clay mud (based on 72 lb mud from yield tables).....	$ 0.485	$ 0.945	195%

Comparison of some unit costs on a basis of 100 percent for 1947 prices gives an interesting picture of today's drilling costs. Table 2 shows that well costs have not increased as rapidly as the unit costs of some of the items used in drilling and completing wells. The cost of tubular goods was computed on out-of-stock prices for 8⅝-in., 32 lb and 6⅝-in., 24 lb casing and 2½-in., 6.5 lb tubing, all of J-55 grade. The costs indicated for mud were based on a straight clay-water mixture. Had gels and mud chemicals been included the percent increase would have been somewhat lower since the cost of these items is approximately 140 percent of 1947 prices. The obvious conclusion drawn from these data is that we are making savings by drilling our wells faster, using smaller sizes of casing and employing modern techniques and tools to get the job done quicker and cheaper.

What Lies Ahead?

The tenor so far has been in the optimistic vein, giving the feeling that California operators have been doing a pretty good job of holding drilling costs down, and holding out a rosy view of the future. Unfortunately, all is not quite so rosy. The reason is that future development of reserves in California must, for the most part, come by way of: (1) drilling deeper wells to tap heretofore unknown reserves; (2) development of proved or semi-proved reserves in residential areas; and, (3) discovery and development of anticipated tidelands reserves from platforms and islands.

Deeper Wells

Each of these conditions has its own peculiar problems to be overcome and the answers are generally expensive. Deep wells are apt to have temperature problems, hole troubles and abnormal wear of casing and drill pipe. The deeper the holes go the better are the chances of having high pressure formations and lost circulation zones open at the same time. This condition not only costs money to control, it also increases the ulcer count among toolpushers and drilling engineers. Even if no serious problems arise, drilling a deep hole costs more through heavier grades of pipe, more conscientious mud control, reduce bit footage and considerable increase in trip-time.

Residential Drilling

Drilling in residential areas has been increasing rapidly during the past few years and along with it go higher drilling costs. In this instance, however, the higher costs are generally not of a direct drilling nature, for most of these wells could be drilled quite nominally

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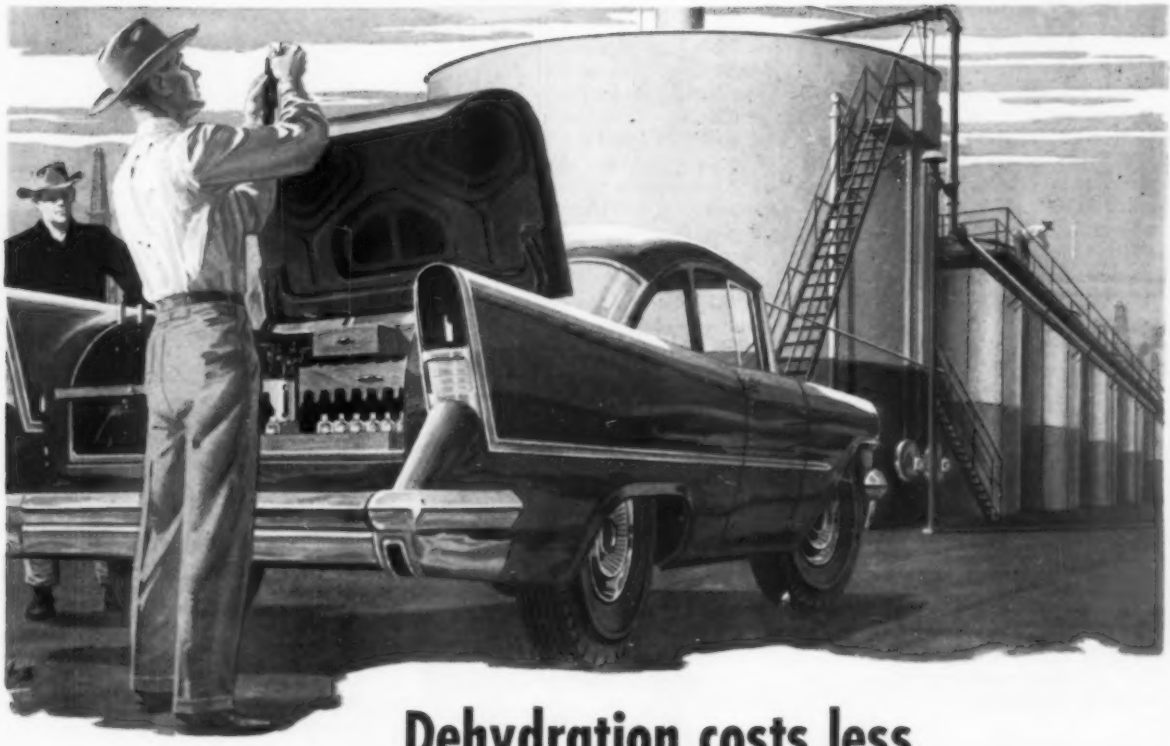

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under normal circumstances. Here the restrictions imposed by regulations and codes and the normally incidental requirements grow to major proportions. Soundproofing, waste disposal, the added cost of directional work and downtime caused by restrictions against certain operations during the night time hours add a big part to the bill for these wells. In addition, the location must be fitted with expensive cellars to house the subterranean wellhead equipment and then landscaped to hide or beautify such equipment as must stay above ground level. The drilling equipment itself must sometimes be modified or rearranged to fit the small drillsite provided.

Fig. 4 illustrates graphically the additional costs imposed by drilling from restricted residential drillsites. The values shown are based on a well drilled to 4000 ft vertical depth at an average drift angle of 45 deg after normal build-up. Total depth of such a well is approximately 5300 ft and requires about 25 days for completion. Wells drilled at lesser or greater drift angles will have proportionately lesser or greater costs. Table 3 itemizes the extra charges for residential drilling.

Fig. 4 shows an increase of nearly 50 percent over the cost of drilling a straight hole from a normal location. Not included in Fig. 4 are the costs of bottom-hole hydraulic pumping equipment and the pumps and storage facilities required for such a system. These are not strictly drilling costs and are used to some extent in normal field operations. They are, however, required for residential areas and must be considered in the overall cost program. Also to be considered is the additional costs imposed on production operations in these areas. Constant supervision of wells, lines and tanks are mandatory to prevent any leakage or spillage of oil. Well servicing is hampered by limited space and local regulations, and all tools, spare tubing, and supplies must be hauled to and from the well sites because of the lack of storage facilities.

While on the subject of residential drilling it might be well to add another thought even though it has no immediate relation to drilling costs. For many years the general public has had quite understandably strong objections against drilling operations anywhere near residential sections. In recent years, however, the operators working in these areas have, by means of up-to-date techniques and equipment, done much to alleviate the situation. For the good of the industry as a whole it behooves each individual member of the industry to do his part in furthering these better relations with the public.

Offshore Drillsites

Development of the tidelands from platforms and islands has in many respects the same problems as residential drilling. Here, too, the industry must overcome the public objections to drilling operations along the coast. This means expensive landscaping of filled islands or the development of ocean floor wellhead equipment and gathering lines for wells drilled from barges. In this type of operation, transportation and supply become major cost items since sufficient inventory of certain materials must be kept on hand to handle emergency needs. Weather conditions can cause expensive delays in drilling operations, and, as in residential drilling, the cost of waste disposal and directional drilling adds to the cost per well. Finally, the drillsite itself whether it be a platform, barge, or filled island adds its share to the bill, and that share is bound to be big.

The cost of an offshore drillsite will, of course, depend on its size, type, and the depth of water. A six-well, self-contained platform of the type used in drilling in the Gulf of Mexico will cost approximately $750,000. A tender type platform of the same size costs approximately $400,000. Daily operational costs for these types of drillsites are estimated at $5000 and $8500 per day.

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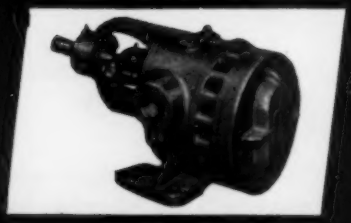

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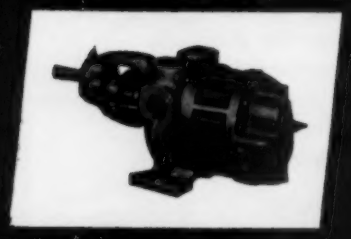

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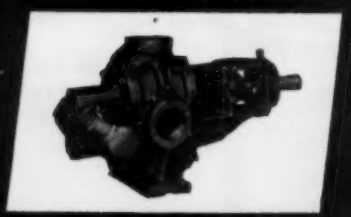

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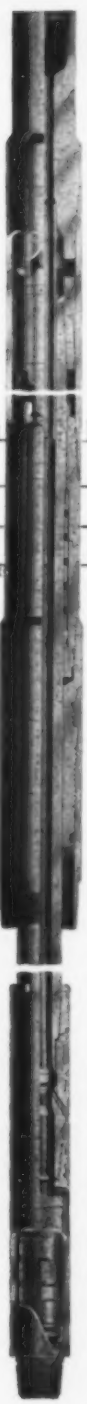

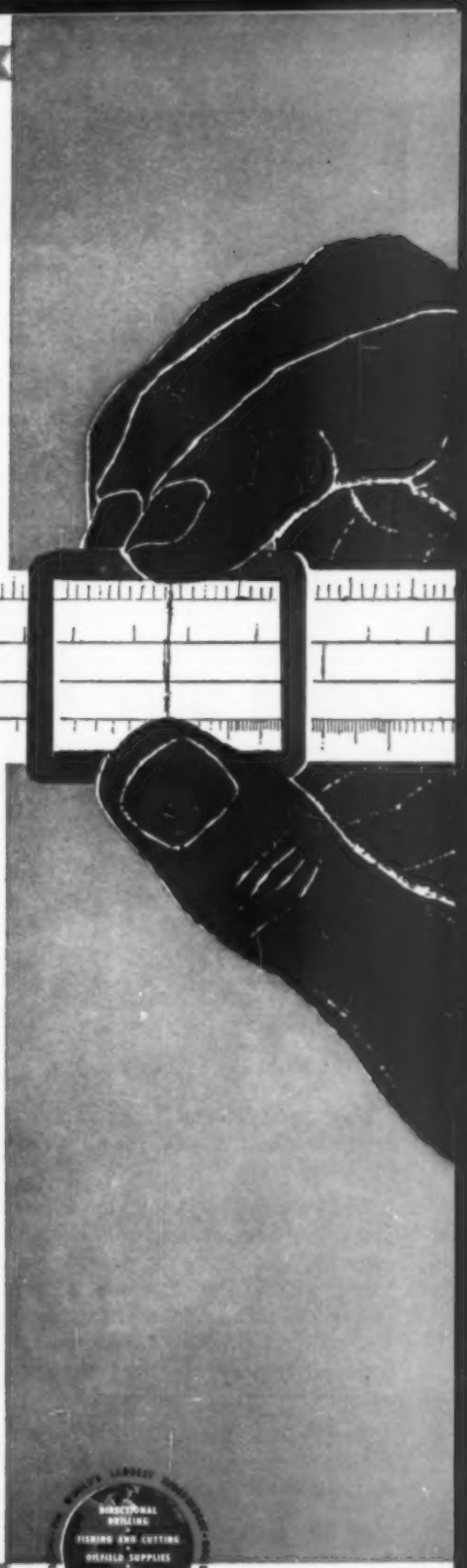

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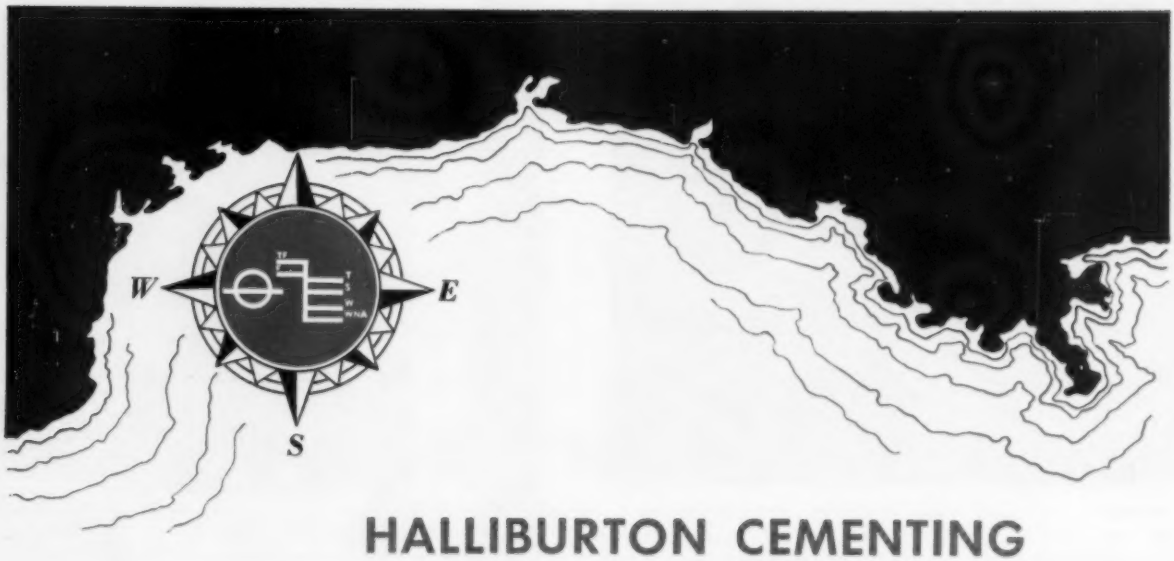

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Seagoing oilmen and cementers team up on the toughest of jobs... with onshore effectiveness.

When you call for Halliburton Offshore Cementing Service, specially designed cementing ships carry the same powerful pumps, wide variety of cement, additives and tools... and the kind of experienced cementing crews... that have successfully cemented more wells than any other cementing company in the world.

To be sure of the best in offshore casing and formation protection, call for Halliburton Offshore Cementing Service.

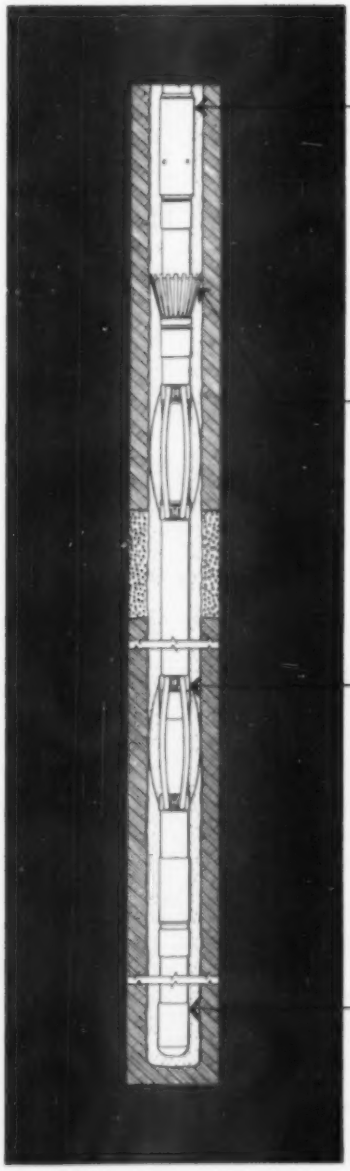
HALLIBURTON

OIL WELL CEMENTING COMPANY

DUNCAN, OKLAHOMA

HIGH COST OF OFFSHORE WELLS MAKES GOOD PROTECTION A MUST

Offshore drilling costs normally run many times higher than other wells and remedial operations are comparably high. Good cementing is a must to protect costly casing and minimize remedial operations. That's why more oilmen call for Halliburton offshore cementing. Here are a few of the tools that help Halliburton's seafaring cementers do an outstanding job.



HALLIBURTON'S "DV" MULTIPLE STAGE CEMENTER

... solves many primary cementing problems encountered in the deeper-than-average holes of coastal and offshore fields. With special plugs and a baffle, two- and three-stage jobs on the same casing string are possible ... in continuous operation or at desired intervals ... using the same or different types of materials in each stage. Designed for positive fluid shut-off by means of hydraulically operated dual sleeves and high-pressure packing.

HALLIBURTON CEMENT BASKETS

... often used below "DV" Multiple Stage Cementer to retain cement and protect weak formations by reducing slurry loss or formation breakdown. Run on outside of casing or liner at point above weak or porous formations. Basket provides bridge, helps support cement column until it takes initial set.

HALLIBURTON'S HEAVY-DUTY CASING CENTRALIZERS

... used in wells offshore where deep directionally drilled holes require extra support for casing. Minimize channeling, aid in uniform placement of cement, thereby reducing later remedial expenses. Hinged for quick installation. Also S-3 centralizers (for average conditions) and Slim Hole types where needed.

SUPER SEAL FLOATING EQUIPMENT

... float shoes and float collars with more than twice the sealing area of usual ball-and-seat valves ... for positive shutoff against back pressure.

SUPER SEAL FLOAT SHOE

CEMENTING SERVICES

OFFSHORE SERVICE ... A SHORT RUN FROM YOUR RIG

respectively, when operating some miles offshore, as in the Gulf area. Such drillsites located nearer docking facilities would cost only slightly less to operate.

Filled island drillsite costs depend largely on the depth of the water in which they are located. As a result, the depth factor imposes certain economic limits on where such drillsites are feasible. A rough estimate of the cost of a filled island in 40 ft of water is about $800,000 plus $10,000 per well location.

The specialized types of drilling operations present an even greater challenge to try to lower unit costs. Much will depend on what is forthcoming from design boards and research laboratories and how well these new tools and materials are used. In any event, it is beginning to look like the drilling picture in California is getting a pretty expensive frame.

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1. "Petroleum Facts and Figures," American Petroleum Institute, Twelfth Edition, 1956.
2. "Well Costs Flatten Out at 1950 Levels," Douglas Ragland, *Oil and Gas Jour.*, Nov 19, 1956.
3. "Contractors Drilled More with Fewer Rigs at Lower Prices," *Drilling Contr.*, February 1957, pp 55.

★ ★ ★

Hopes lie in the youth that is attracted to the drilling industry;

Future depends on the contractor's ability to trim waste and overhead

CONTRACTORS' Plans and Hopes For the Future

John S. Hagestad

John S. Hagestad Drilling Company, Bakersfield, California

THE oil industry, demanding more tools, encouraged the drilling contractor to pull himself up by his boot straps without adequate training for the full job ahead. His business progress must be built on service and respect, not on the philosophy of boom or bust.

Drilling businesses must institute a program of education to attract young men of superior quality and stamina. Generally these young men have a background of service in the various organizations that support the oil industry. Through this spirit of service will come cooperation that will replace the rugged individualism that has been so typical of the drilling contractor in the past.

With footage rates at lowest level in history, there is little chance of improvement. For a contractor to survive he must obtain increased economy with less waste and increased mental alertness for better efficiency. This is no unusual condition, it is common to all business.

Up Through the Ranks

The history of the drilling contractor has been the gradual evolution from roustabout to driller to rig owner. It is only natural, having spent a lifetime in the oil fields, that his drilling ability along with the care and maintenance of tools and control of field personnel are of the highest caliber. In the complementary fields of business such as accounting, public relations, management and industrial leadership, the drilling contractor has not met his responsibilities. In effect the boss has pulled himself up by his boot straps without adequate training for the full job ahead.

This paper was presented at the spring meeting of the Pacific Coast District, American Petroleum Institute's Division of Production, Los Angeles, California, May 16, 17, 1957.

The period of 1943 to 1946 was a trying period for the drilling business, and yet it was also the period when the drilling contractor started his great forward progress. This was a period when equipment and manpower were very poor. With complete cooperation from the operator, however, the job of finding and producing more oil was successfully accomplished. With flexibility of operations that a major operator cannot match, the drilling contractor has practically eliminated company-owned tools.

One would be hard pressed to find a business that is more hazardous than that of the contractor. More business failures occur in the contracting business than in any other type of business. The drilling contractor's position is more vulnerable than other types of contracting business. In the event of an unsuccessful job little material or labor can be salvaged. There is no intermediate payment for footage work. Despite all the laws regulating the conduct of business, there still is no law that prevents a contractor from going broke if his business management and inadequate financing create the condition.

Government Control

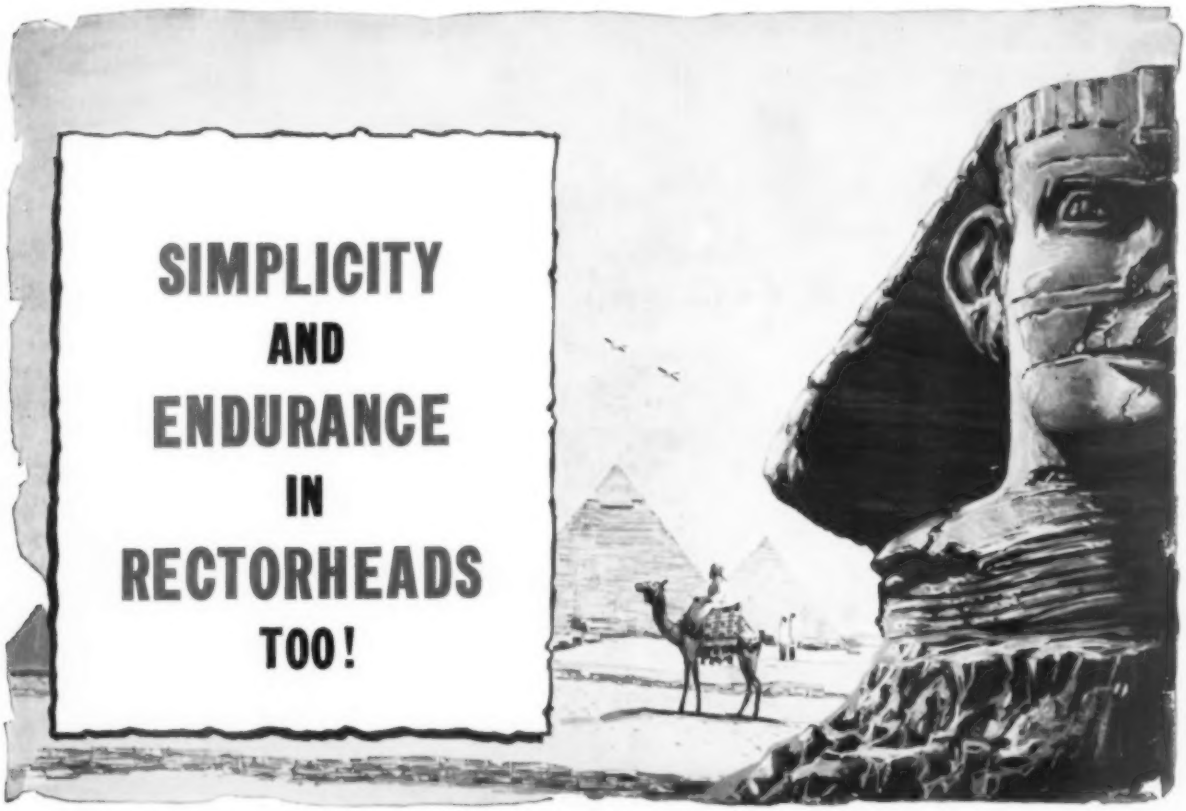
How different our situation would be if the drilling business were regulated by the Public Utilities Commission and all oil fields had firmly established drilling rates or the regulation of all drilling rigs was controlled by a State Oil and Gas Commission, and the number of drilling rigs available for work was prorated by this commission in the same manner oil production was to be controlled in the recent oil bill.

Even against what appears to be insurmountable odds the drilling contractor has been able to improve his position. These are some of the impositions with which the contractor must deal:

a. Footage work is being expanded to include more and more drilling operations.
b. Total mud costs are being borne by the contractor, yet he is at the mercy of operator's mud engineer.
c. Contractor is forced to assume risk while performing hourly work.
d. The harsh and unreasonable lost circulation clauses are being included in some contracts.
e. Operators are demanding the cash discount when it is the contractor's promptness that earns the discount.
f. Changes are being made in drilling programs, depths, hole sizes, casing sizes, without adequately compensating contractor for additional expense.

Some operators justify the demand for additional services under the footage contract by contending the contractor has more control over operations. Such action penalizes the careful contractor who may not be the low bidder and rewards the low bidder who may be a careless contractor. It is extremely difficult to add the additional cost of these services to the footage price during periods of a declining market. Every footage bid demands a specified number of hours be made part of the footage work. Again the contractor has been able to do this without cost to the operator.

The drilling contractor has made many accomplishments. He has developed an industry from a few; the number could be counted on both hands,

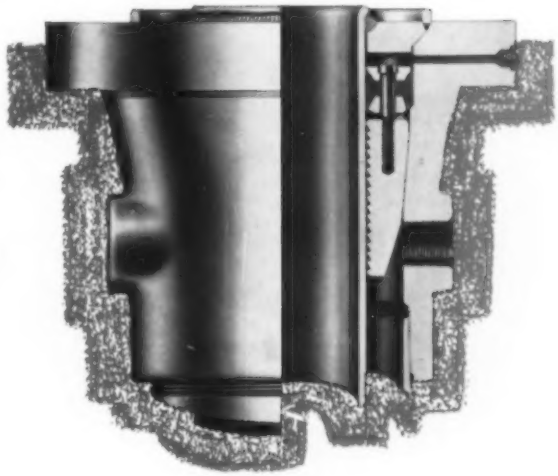


The ring-of-steel seal employed in RH Casing Heads is unmatched for simplicity and endurance. In oil fields throughout the world it has survived fires — endured for years without leaking or replacement.

The patented welding ring, welded to the pipe and sealed at the head body with API ring gasket is simplest of all to install. ***The welding ring prevents any well or frac pressure being transmitted to the slips, creating a hydraulic force which would collapse or crush the pipe.***

There is no soft or resilient packing to "flow" under high pressure or temperature; to "freeze" and contract under low temperature; to burn out or deteriorate after years and years of service. Positive proof of this endurance is to be found in more than 100,000 Rectorheads now in service.

At authorized supply stores everywhere.



RECTOR WELL EQUIPMENT COMPANY INC

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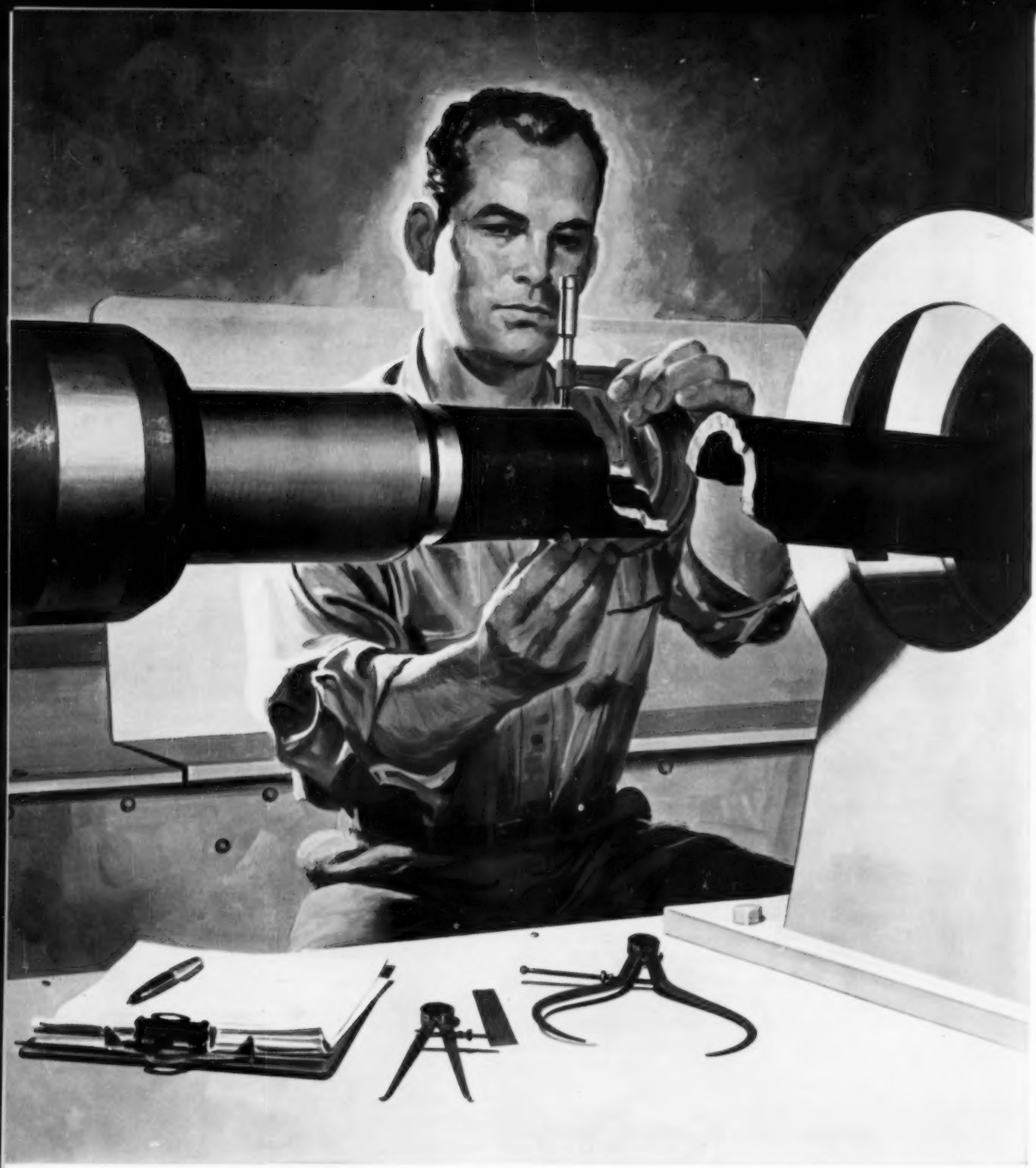
REPRESENTATIVES IN ALL ACTIVE FIELDS



Hughes Engineering and Research Developments

1919 First heat-treated alloy steel tool joint — to make the use of tool joints economically feasible.

1929 First bucked-on tool joint with controlled torque — to minimize washouts.

1933 First bucked-on and welded joint — to prevent last engaged thread failures.

1937 First bucked-on and counterbore welded tool joint — to reduce welding cost for the operator.

1938 Introduction of *first unitized drill stem* — after three years of full-scale research into flash-welding process.

1942 Introduction of hardfacing in depth on "Flash-Weld" tool joints — to lengthen the life of joints.

1942 Refinement of flash-welding techniques — to permit use of smaller pipe upsets.

1945 Introduction of copperplat-

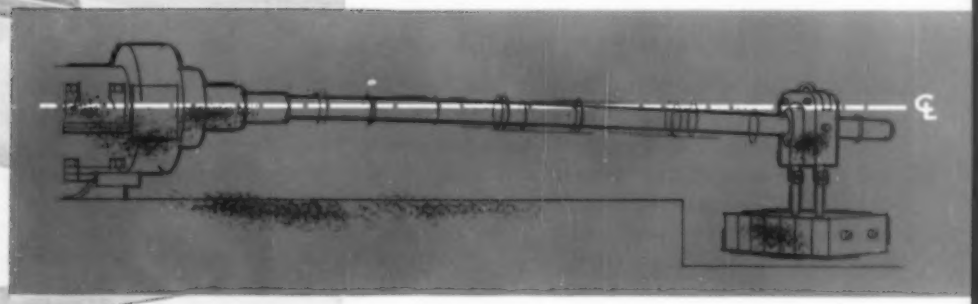
out of CONTROLLED DESTRUCTION comes progress

Three specially designed rotating fatigue machines are kept in operation 'round the year testing drill stem to destruction.

Pioneered by Hughes as early as 1931, the use of fatigue machines has contributed importantly to the advancements made to date.

These machines are now being used in one of the most extensive programs yet undertaken. The purpose: to provide improved tool joint-to-pipe connections to meet the higher stresses of deeper drilling anticipated in the years ahead.

Always out in front, HUGHES' continuing research assures the operator that his drill string — for the *present* and the *future* — will have the most dependable tool joint-to-pipe connections that he can run in the hole.



ing of box and pins — to minimize galling.

1947 Stress-relieving of weld zones in high alloy and all other grades of pipe.

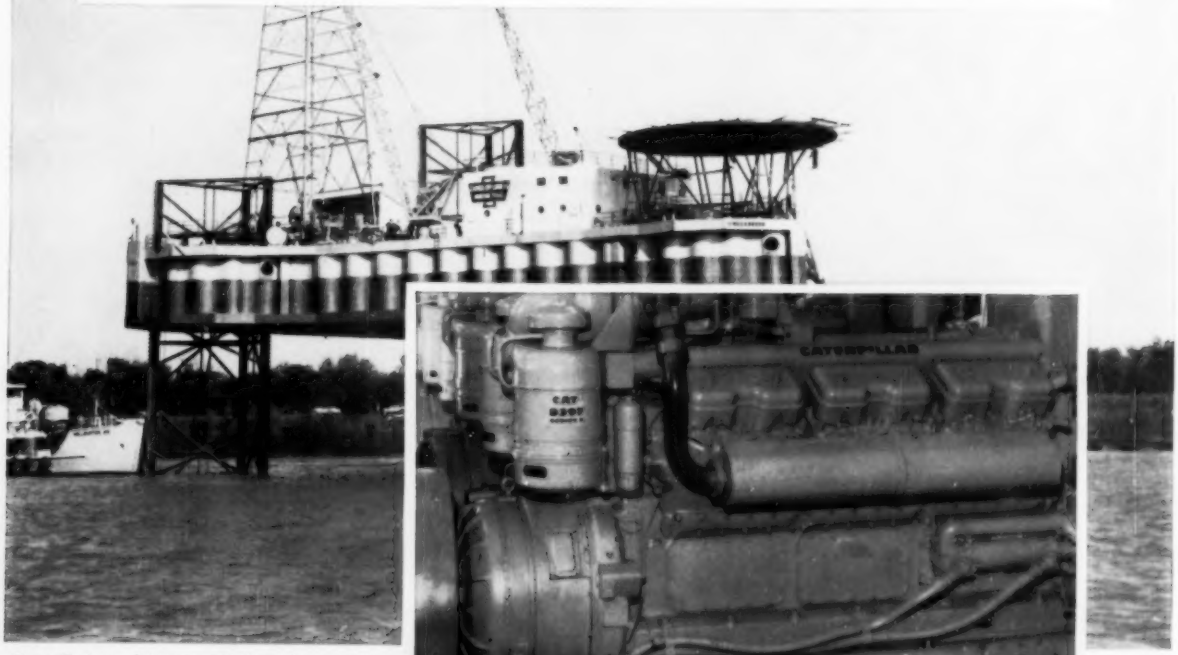
1956 Development of techniques and equipment for cold-rolling large land area of pipe — to strengthen pipe and "Seal-Grip" tool joint assembly.

1957-'67-'77... Continuation of the search for the new and better tools for tomorrow's needs.

Developers of Flash-Weld, Seal-Grip and Guiberson Weld-Rok Joints

HUGHES
TOOL COMPANY
HOUSTON, TEXAS

Here's how Zapata puts torque to work on new off-shore rig...



Over-all view of Zapata Off-Shore Company's new drilling rig, the *Vinegarroon*.

Close-up of one of the four Twin Disc 16,000 Series Three-Stage Torque Converters which transmit power from four Caterpillar D397 Engines to the drawworks, rotary table and mud pumps on the *Vinegarroon*.

ZAPATA OFF-SHORE COMPANY'S new *Vinegarroon* is truly a modern, heavy-duty drilling rig in every sense . . . from its adjustable tripod legs to its helicopter landing field.

Built by R. G. LeTourneau, Inc., it carries a 140-ft. derrick, an Oilwell Model 96 Drawworks and four 575-hp Caterpillar D397 turbo-charged Diesel Engines equipped with Twin Disc Three-Stage Torque Converters. Two of its three mud pumps alone are rated each at 925 input horsepower at 65 revolutions per minute.

The Twin Disc Torque Converters in this installation are compounded to transmit power to the mud pumps, drawworks and rotary table. As mud pump pressures increase, the Twin Disc Torque Converters instantaneously multiply engine input torque to meet the increased requirements. It's the same with the drawworks, where the load varies continually as the hole deepens, and with the rotary table, when tough material is encountered.

Twin Disc Torque Converters offer many other profitable advantages, too. They cushion out destructive shocks and vibrations between engines and driven equipment . . . they prevent engine stalling . . . they permit engines to produce maximum output whenever required, regardless of load . . . and they get more work done wherever varying loads are encountered.

Be sure to specify Twin Disc Torque Converters, three-stage or single-stage, on your next oil field equipment. They are available from all leading oil field equipment and machinery manufacturers.

Twin Disc Clutch Company, Racine, Wisconsin; Hydraulic Division, Rockford, Illinois . . . with parts and service throughout most of the world.

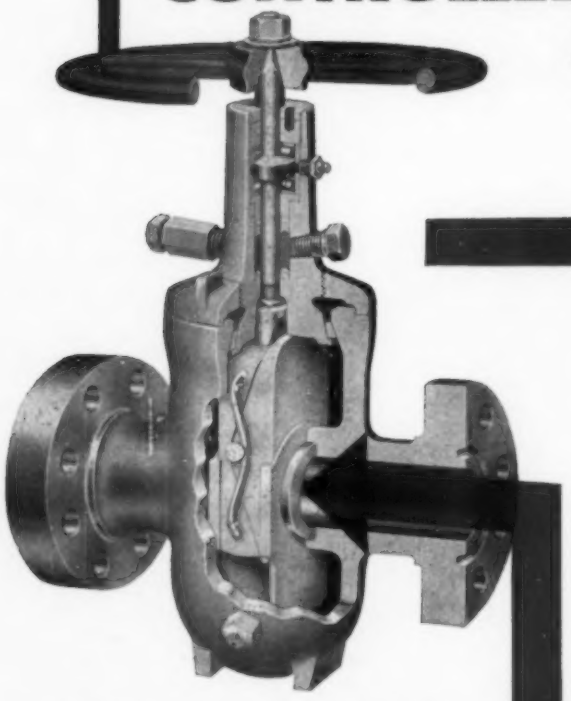
TWIN DISC
CLUTCHES AND HYDRAULIC DRIVES

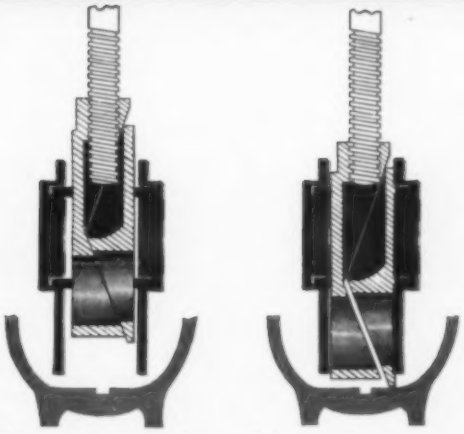
TWIN DISC
Torque Converters

CONTROLLED FORCE SEATING

UPSTREAM AND DOWNSTREAM

W-K-M VALVES





While opening and closing, gate and segment are in collapsed position — move freely between seats.

Gate and segment expand when seating position is reached. The more torque applied on the stem, the tighter the seal becomes.

Specify W-K-M *Valves for christmas trees, flow wings, and all installations. Available in sizes 2" to 4"—working pressures from 500 lbs. to 15,000 lbs. Sold through Supply Stores everywhere.*

For design and operating features, sizes, pressures and complete dimensions, write Dept. F-701 for W-K-M Through-Conduit Gate Valve Catalog 200.

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It takes force to seat and seal a valve against pressure. The parallel expanding gate in W-K-M® Through-Conduit Valves gives you this force, *but only after the gate reaches closing position.*

This force is applied simultaneously and equally to both seats. It is controlled by the torque applied on the valve stem. It is not and cannot be applied while gate is moving, because the gate and segment are held in a collapsed, free-moving position by means of alloy steel gate springs.

When the gate and segment reach closing position, the segment stops while the gate continues to move downward, forcing both the gate and segment against the two seats. The tighter the valve is closed, the greater the sealing force applied to the upstream and downstream seats.

When the valve is opened, torque on the valve stem releases the sealing force so that the gate and segment move freely to a fully open position.

With W-K-M's "CONTROLLED FORCE" seating, you always have a leakproof seal upstream and downstream.

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MANUFACTURERS OF W-K-M GATE VALVES · acf LUBRICATED PLUG VALVES · KEY-KAST ALLOY STEEL PIPING FITTINGS · KEY RETURN BENDS AND FITTINGS

to over 75 independent drilling contractors in California, and he has reduced operator owned rigs from a dominant to an insignificant position. Today less than 12 percent of the rigs operating in California are operator owned rigs. Through increased efficiency of operation with more rotating hours and increased efficiency of maintenance with less waste, the drilling contractor has been able to hold the footage drilling prices at the same level, or lower, than they were 5 to 10 years ago. While holding the line on footage drilling prices, the contractor has had to overcome the following factors:

a. In 10 years wages have increased 100 percent.
b. In 10 years the cost of steel has increased 85 percent.
c. Between them, wages and steel comprise 67 percent of the contractor's cost. Increase in these items are typical of every item necessary to run a rig.

Drilling contractors are proud to be part of an industry that has given the people of this nation a better finished product called gasoline which has remained reasonably constant in cost for the last 10 years. That is the reason the oil industry is proud to say: "Three will do the work of four." But, with greater pride do the drilling contractors point to their accomplishment over the last 10 years for now two rigs do the work of four.

Future of the Industry

The future of the contract drilling business can be compared to the Los Angeles weather. When smog covers the city, you can see little ahead. When wind comes and drives the smog away, the sky is clear and the future bright. On the dark side of the drilling picture, we find our present oil fields have been well drilled with close spacing, our exploratory program is dragging from lack of incentives and restrictions and limitations hinder offshore work. On the bright side of the drilling picture are possible expansion of offshore work, continued drilling of former marginal areas, future exploration of the vast West Coast area, and redevelopment of many fields to prepare them for efficient secondary recovery methods. Also, to help us in our search for more oil, will be the efficient use of slim-hole drilling, air drilling, turbo drilling, sand fracturing, better equipment design, better steel, and the old favorite, better mud pressure-volume relationship.

Essentially the drilling picture has not changed much since 1939. The feeling at that time was "California is running out of places to drill." Since then we have drilled over 30,000 wells. Today the same attitude is evident, "Where do we go from here?" In the author's opinion, during the next 20 years there will be drilled—in our present producing areas—at least one well to every three presently producing. The drilling business is an integral part of the oil industry which today and for the foreseeable future will have the greatest expansion of its dynamic life.

As the oil industry builds to deliver more and better products, the drilling contractor must develop to serve better. The contractor must become a responsible component of the oil business. His business ability must be built on service and respect, not on the philosophy of boom or bust. Through cooperation all contractors must unite to improve public opinion regarding the oil industry. They must contribute part of their skill and knowledge to community interests.

Education Vital

The drilling business must institute a program of education to attract young men of superior quality and stamina. An excellent start has been made particularly with the help of the American Association of Oilwell Drilling Contractors at Odessa, Texas, and the American Petroleum Institute courses offered at various junior colleges. The drilling industry is a good place for a young man to start. With an alert mind and active body he will learn the terrific team work that comes from being a member of a good rotary crew. There are many opportunities and many directions he may take to achieve a successful and rewarding life in the drilling business but first he must learn the operations. The only way is to join a rotary crew.

Many drilling contractors are disturbed about the continual reduction of footage prices. Two conditions have existed. Footage prices as were known 10 years ago were too high. Competition had to force them down. Secondly, because competition is so keen the prices have been forced dangerously low. Now again, looking to the future, the conditions that exist today are normal, and the prices that are currently being quoted are prices that drilling contractors will have to live with. In order to meet this challenge, the drilling contractor must sweep his house clean of all waste, inefficiency and mental inaptitudes.

The drilling contractor is improving his stature as a business man, but until each one feels a moral responsibility for the welfare of the oil industry and for the welfare of his community, he will stand alone. The only way one can shoulder his responsibilities is to take part in them. There are many ways to do this: By supporting the American Petroleum Institute and the American Institute of Mining, Metallurgical and Petroleum Engineers meetings in local areas; contributing to the Oil Industry Information Committee; promoting the welfare of trade associations, the American Association of Oilwell Drilling Contractors and the California Contractors Association. These organizations are voices in telling the public the oil business is healthy and competitive with no hidden gimmicks.

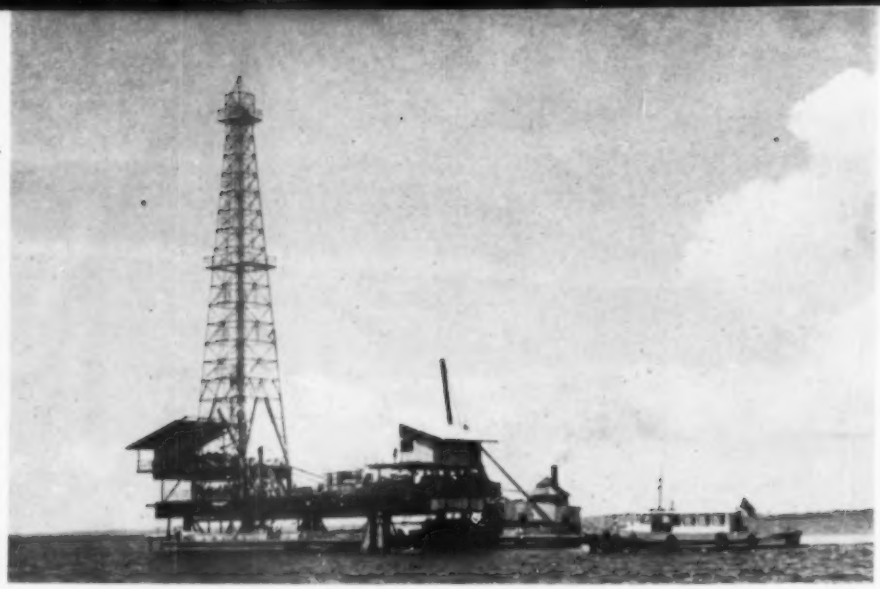
"Individualism" Era Gone

The present day drilling contractor must separate himself from the rugged individualism that has been characteristic in the past. During the years our trade associations have grown and offered a great deal of help. But the average contractor will not accept this help; he feels his problems are not common to the group. With this feeling it is impossible to get cooperation from a large majority. That is why this author suggests that each support oil industry functions and, through these efforts, a better understanding of each other's problems will come. Perhaps then rugged individualism can be thrown away, and the drilling contractors can team together to present a unified voice. When that day arrives the drilling contractor can take his seat at the "Council Table" of the oil industry, and until that time comes the smog will hover over the horizon.

These are the changes that have taken place.

a. The oil industry demanding more tools encouraged the drilling contractor to pull himself up by his boot straps without adequate training for the full job ahead.
b. The drilling contractor's position is more vulnerable than other types of contracting business.
c. Rate of penetration and efficiency have been increased to the extent that two drilling rigs can now do the work which formerly required four rigs.
d. There has been a dynamic expansion in the oil industry to meet the ever increasing needs for petroleum products.

The challenge is squarely before the drilling contractor. The work will be made available by the increasing demand for the products we seek. To meet competition and the low cost of drilling, the contractor must eliminate all waste and unnecessary overhead. Through the spirit of young men accustomed to supporting oil industry functions may come the cooperation necessary to unite the drilling contractors as a potent voice to help fight the problems of the oil industry. These are the hopes for the future. ★ ★ ★



First offshore drilling rig in Trinidad waters. The well is being drilled by Trinidad Northern Areas, Ltd.; one-third interest in it is held by BP Exploration Company, an exploration subsidiary of British Petroleum. Well is in about 40 ft of water about 14 miles from Point Fortin. Nearest land is Cedros approximately seven miles away. — BP photo

Island oil production falls, now . . .

TRINIDAD Looks Offshore

Exploration begins in Gulf of Paria for extension of fields existing in Venezuelan waters

OFFSHORE exploration is in sight for the island of Trinidad. Onshore fields, most of them old and declining in production, are reaching a point of diminishing return, although average daily production is about 79,000 bbl.

Coastal concessions are already yielding oil from shore-based horizontally-drilled wells and are offering new hope of meeting the crude demands of Trinidad's three refineries.

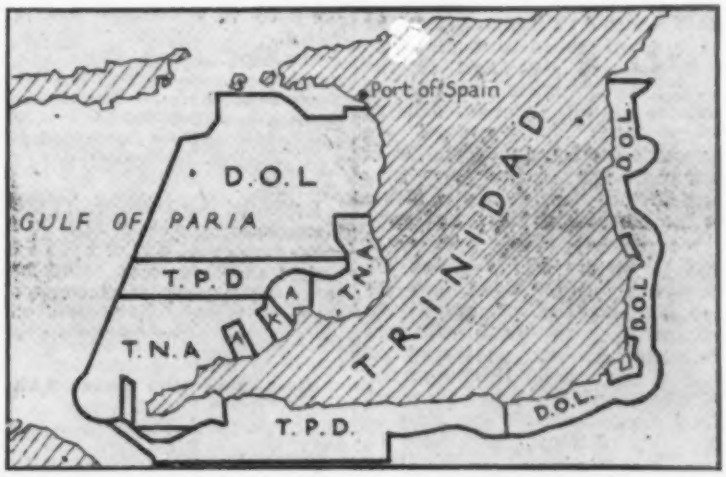
Stemming from difficult geological conditions and low productivity per oil well, Trinidad is one of the highest producing cost areas in the world. From 1941 to 1952 the island's total petroleum output was virtually static, and production per well per day was on the decline. About 98 percent of the fields are pre-war discoveries in spite of intensive exploration since then, and the majority are 40 years old or more.

Trinidad's proved petroleum reserves are of the order of 285,000,000 bbl. In mid-1956 there were 2837 producing wells and 27 were being drilled last September. Twenty-six drilling rigs were operating, and during the first half of last year 113 wells were completed, and there were 12 dry holes. The average daily production was 79,000 bbl, and cumulative output until the end of last June was 541,000,000 bbl. The island's three refineries have a combined crude distillation capacity of 137,000 bbl per day.

The three leading producers—Trinidad Petroleum Development (TPD), Shell Trinidad and Trinidad Oil—account for over three-fifths of the island's total production. Two others, Trinidad North Areas (TNA), and Kern Trinidad Oilfields have struck oil in their coastal concessions by deviating wells sunk in the beach. As a result, the island's petroleum production in 1956 rose by 16 percent over the preceding year—the largest increase during the past 15 years.

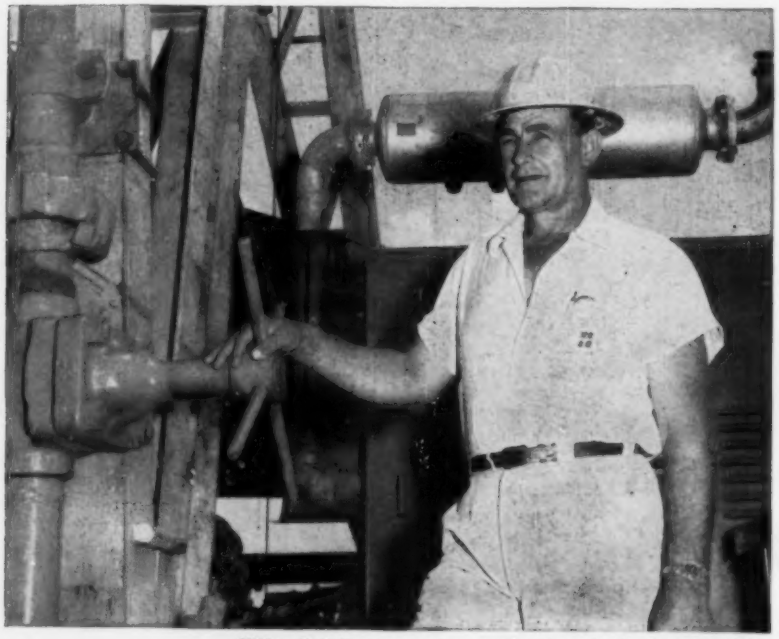
The one ray of hope in an otherwise gloomy picture is offshore exploration. Marine concessions have already been granted off the east, west, and south coasts of the island. To the west Trinidad is separated from Eastern Venezuela by the shallow and sheltered Gulf of Paria, and the same geological structures that have yielded oil on the mainland are deemed to extend across the gulf.

Virtually the entire Trinidad shore of this gulf region has been farmed out in concessions. The main sectors including the whole "high seas" area have been allotted to Dominion Oil, TPD and TNA. Dominion Oil, a wholly owned subsidiary of California



Offshore leasing off Trinidad is almost complete as shown here. Companies holding the leases are: Dominion Oil (DOL); Trinidad Petroleum Development (TPD); Trinidad Northern Areas (TNA); Antilles Petroleum (A), and Kern Trinidad Oilfields (K).

Tips on Mud Valves for Toolpushers . . .



"Woodie" Farris, veteran toolpusher, finds MUDWONDER Valves superior to others he has used

Non-clogging MUDWONDER Valves are real oil field favorites!

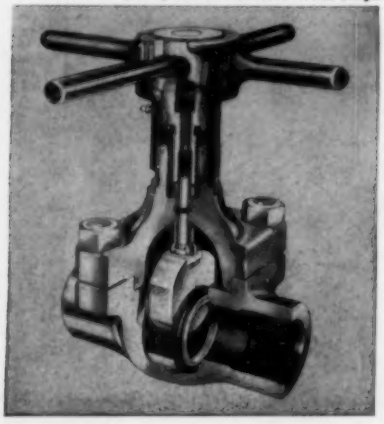
by Woodrow Farris, Toolpusher, Rig #3
Kilroy Drilling Company, Alvin, Texas

NEARLY five years ago, I was pushing tools on a Gulf Coast rig. Some of the first test models of the MUDWONDER were installed on it. At first they seemed like just another mud valve . . . but then I noticed the MUDWONDERs simply didn't "sand up" like other types. Began to keep an eye on those Rockwell-built MUDWONDERs . . . and, by golly, they really stood out!

After the second or third hole, we knew we *had* something. The new MUDWONDERs just didn't clog. Even under worst conditions there was never more than a teaspoon of sand in the bonnet—and even this usually flushed free in the flow of mud.

There was no shut-down for cleaning. When essential, repairs could be made without down-time. The one-piece MUDWONDER body stayed right in the line. Rig personnel really *liked* the MUDWONDERs . . . said they were the cleanest and easiest to operate of any mud valves we'd ever used. Yet they cost us no more than ordinary mud valves.

MUDWONDER cutaway view shows the double thread construction, separated stainless stem and hard chromed gate with "T" slot connection, and the one-piece seat insert with the buna-N molded integrally over the steel wear-rings.



Now, when Kilroy Drilling Company bought our present Rig #3, it was second-hand but almost new. There were a few MUDWONDERs already on it. But on the strength of our experience, Mr. John Baker, Drilling Superintendent, and I both were convinced we wanted MUDWONDERs all the way around. So we re-rigged the whole mudline system that way. Good thing, too. In a year of continuous operation, we've spent virtually nothing on repairs and have had a minimum of maintenance.

MUDWONDER Valves are built in 2", 3" and 4" sizes with screwed or flanged ends for 2000 psi WP (4000 psi test) and 3000 psi WP (6000 psi test). See your favorite oil field supply store, or write Edward Valves, Inc., Subsidiary of Rockwell Manufacturing Company, East Chicago, Indiana. ADVERTISEMENT

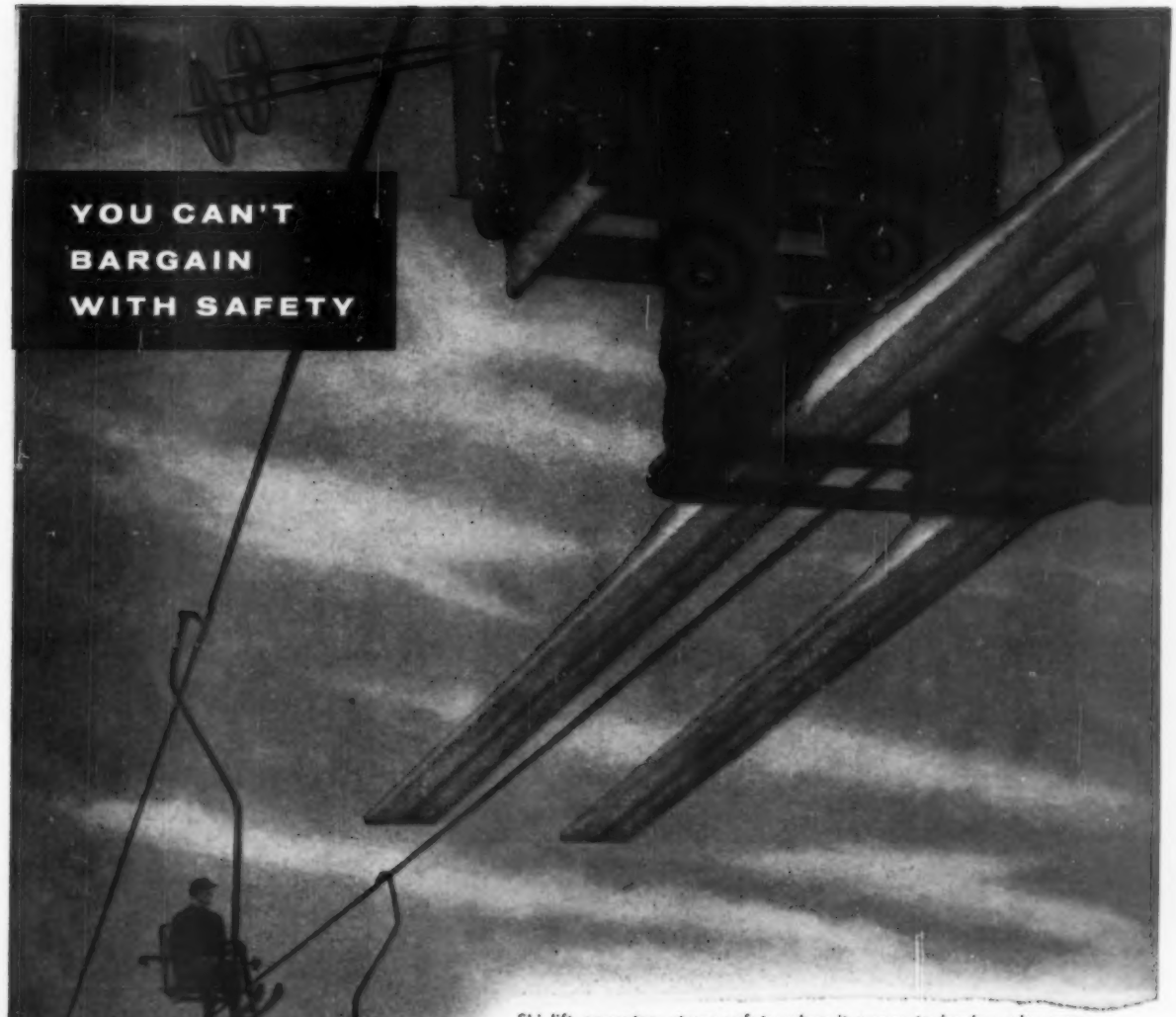
Standard, has by far the largest concession, with over 400,000 acres in the Gulf of Paria alone. Being a newcomer its activities have so far been confined to exploration. TPD's total marine concession covers 225,000 acres, of which 57,000 acres are in the Gulf of Paria.

Owing to the high costs, especially in the large initial outlay, incurred in offshore oil exploration and production, an agreement was reached in 1954 between TPD and TNA to the effect that the latter would operate the former's western offshore area on a 50-50 profit sharing basis. Although TNA has not yet started drilling within TPD's concession area, it has located offshore oil within its own concession.

TNA is a consortium of Royal Dutch-Shell, British Petroleum and The Texas Company, each member has a one-third share. Its concession of 207,000 acres is smaller than either Dominion's or TPD's, but unlike the latter's it is wholly situated in the Gulf of Paria. Its marine exploration began in 1955 and so far three wells have been drilled from the same platform and all have struck oil. TNA's No. 1 Soldado was drilled to a depth of 7500 ft in 1955 from a platform several miles out in the gulf. It was later tested at 450 bbl per day from 4400 to 4800 ft yielding 34 deg API gravity crude oil. All the three wells have until now been shut-in, pending the construction of a 16-mile pipeline to Shell Trinidad's refinery at Point Fortin. This pipeline was scheduled for completion in mid-June 1957. Production from these three wells is about 1000 bbl per day. Meanwhile testing is to begin to discover the full extent of the field and it will probably be some 18 months before this is completed.

Although no offshore drilling has taken place, offshore oil has been found in some of the coastal concessions of TNA and Kern Trinidad Oilfields by deviating wells sunk in the beach. Apart from the Kern Trinidad's concession, the only other minor offshore concession is held by Antilles Petroleum—a wholly-owned subsidiary of the Canadian company McColl-Frontenac, which in turn is a 59 percent owned subsidiary of The Texas Company.

Oil exploration in the Gulf of Paria is still in its infancy and indeed expensive. The cost in respect of TNA's first offshore drilled well was estimated to be five times as expensive as a comparable onshore well, and onshore costs themselves are high in Trinidad. Last year the Trinidad Government granted a depletion allowance on offshore production because of the high costs involved. ★ ★ ★



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A Safe Lift

Even though you don't operate a ski lift, false economy can be costly in your rope purchases, too. For a rope failure can cause personal injury . . . wreck your equipment . . . throw off your entire work schedule . . . and affect employee morale. Yes, a "bargain" wire rope may save you money, yet cost you your peace of mind. Don't take a chance. Buy a rope that's a quality rope—buy Wickwire Rope.

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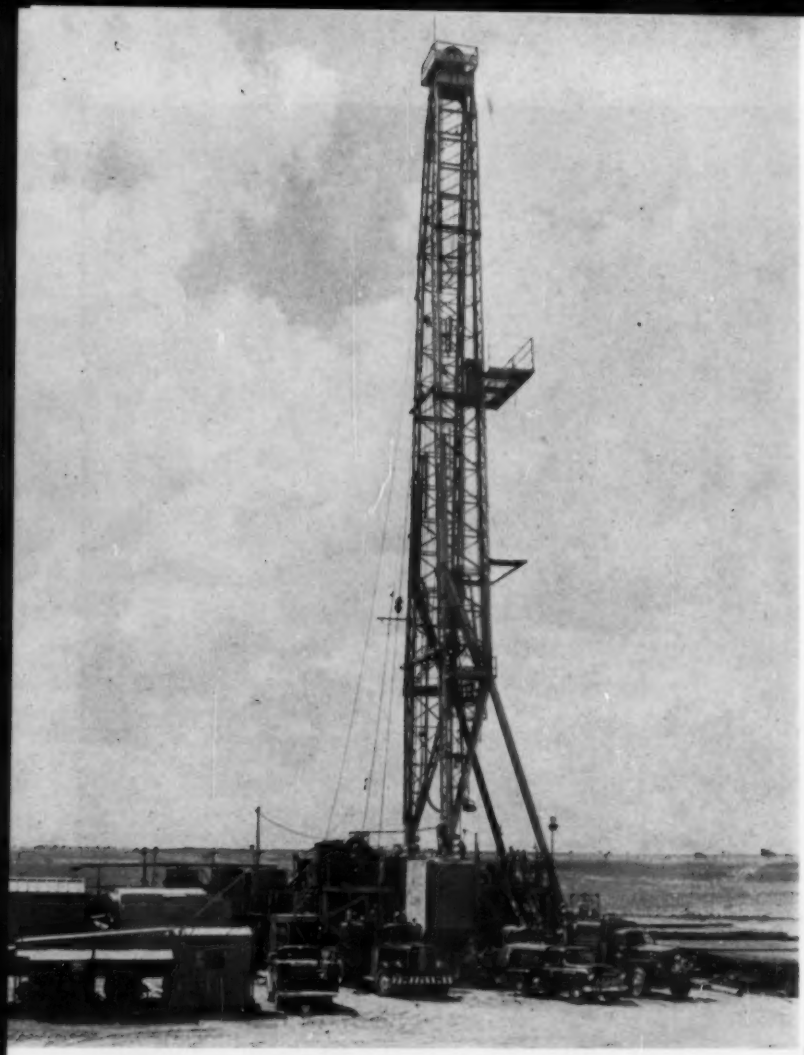


1. **Rig 28** moves once a week when drilling 7000 ft wells in Venezuela. The rig is shown here on location during completion of Caico Seco Well No. 7. In the foreground is the 25 KV generating plant and doghouse. All engines, including light plant engine, are butane powered.

Largest Mobile Rig Proves its Worth

MENE Grande Oil Company's Rig 28 — considered the world's largest trailer mounted rig — is now a year old. In its first year of operation it has drilled and completed 23 wells 7000 to 10,000 ft deep, cut 178,000 ft of hole and traveled over 440 miles in location moves in the Caico Seco oil field of eastern Venezuela.

The company's experiment in mass mobility has proved so successful that it is now taking delivery on a similar drilling giant. Mene Grande operates 28 rigs in Venezuela, 25 of which are steam powered. Costs and operating efficiency of the two types of rigs have been closely studied by company engineers in the past year. Rig 28 seems to meet the demand for fast drilling, rapid rig-up and tear-down and smooth overland moves over the West Texas-like East Venezuelan terrain.

In the rig's operation in the Caico Seco field, about 20 miles northwest of El Tigre, it is called upon to drill and complete the well including setting the Christmas tree and running tubing — operations that require approximately as much time as drilling the hole. On 7000 ft holes, Rig 28 moves every week except where dual completions and and testing do not take over two or three days.

The large rig is designed for 10,000 ft drilling. Drawworks is a double drum unit with a 49⅛-in. long by 22-in. diameter main drum, and a 12¾-in. diameter by 46¾-in. sand reel. Main

2. **Lay down** of the mast is accomplished quickly, since the 143-ft tribble is rarely taken apart for moving. To speed tear-down, most connections are of the quick-disconnect coupling type and used with flexible hoses.

drawworks is powered by three 12-cylinder industrial engines with dual carburation, each with a 350 hp continuous rating. Mast is a 143 ft tribble. Main mud pump has an 18-in. stroke and delivers 933 gpm (maximum capacity) at 1328 psi with 8¼-in. liners; an auxiliary engine is mounted on main pump skid. Stand-by mud pump is a 7 by 14-in. skid-mounted unit and is used for mud mixing, compounding and to provide emergency circulation.

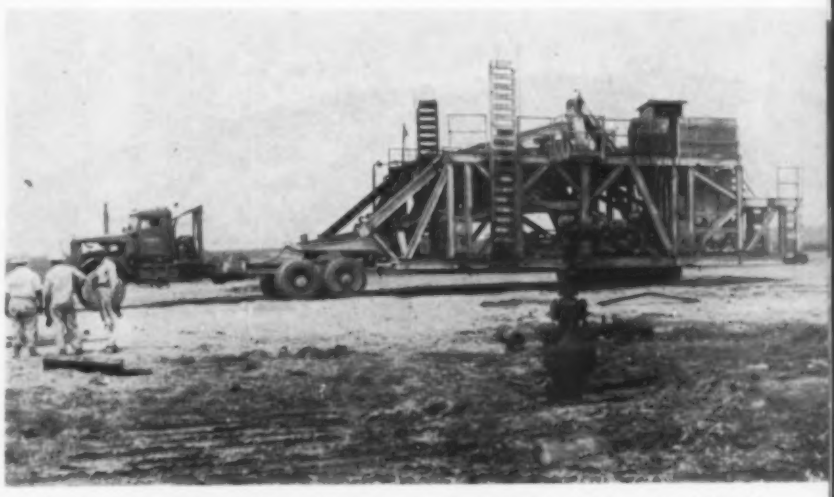
Six truck loads, excluding drill pipe, make up the rig caravan when on the move. One load consists of the three engines, drawworks, engine compound, hydromatic, rotary table and a stand-by fuel tank. All this is mounted on a 65½ ft long by 12⅔ ft wide trailer. Total trailer weight is approximately 150,000 lb. From the ground to the top of the sand reel, the load measures 16½ ft. Eight 18 by 24-in. sand tires support the trailer.

A second trailer is used to transport the 12-ft substructure. A 1500 gal water tank is built into the structure.

Two trucks are used to carry the mast, which is not normally disassembled for moving. Mud pump and stand-by engine makes up one trailer load, and the last load includes light plant, stand-by pump and miscellaneous equipment.

The rig uses butane for fuel, and two trailer mounted butane storage tanks normally accompany the rig.

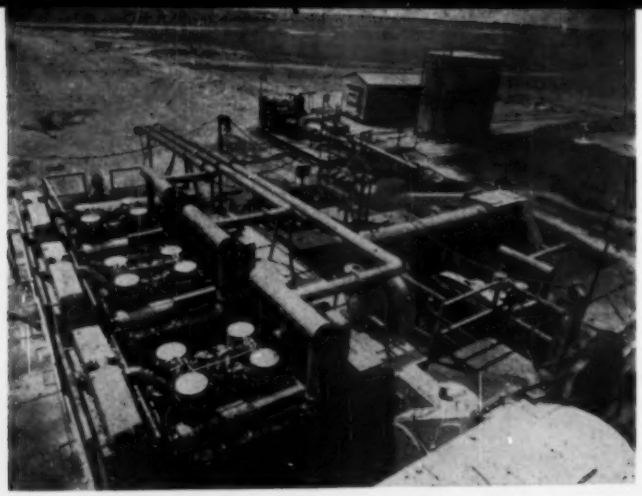
3. **This** 150,000 lb. trailer-mounted load consisting of drawworks, engines, compound, hydromatic brake rotary table and stand-by fuel tank are the guts of the rig.



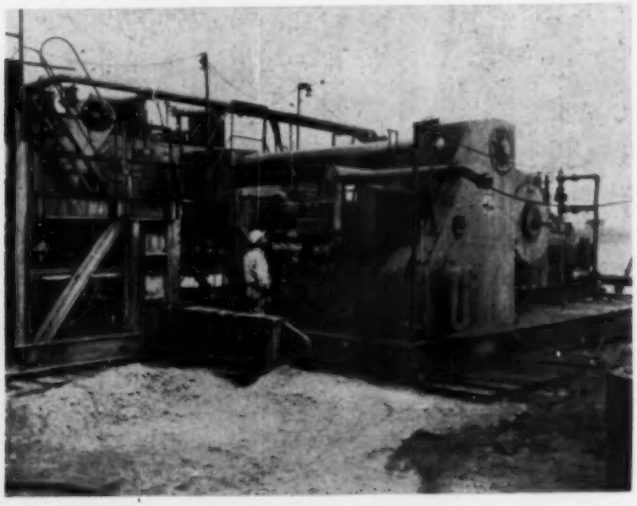
4. **Substructure** of the rig is moved as one piece on one trailer bed. In it is a 1500 gal cool water tank. Blowout equipment is sometimes moved within its U-shaped base.

5. **Mast** is moved in one section by double-heading trucks. Span of the mast legs is 24 ft. Legal road width limit in Texas, in contrast, is 8 ft.

Largest Mobile Rig

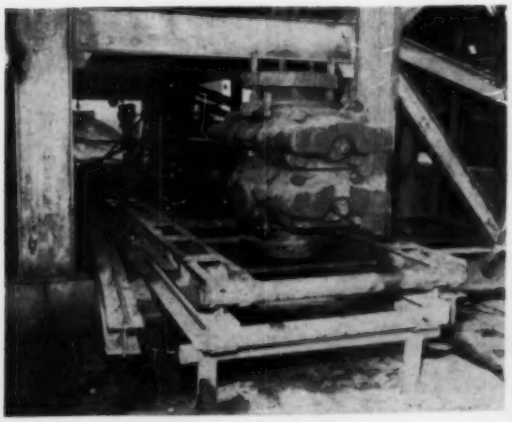


6. **Stabbing board view** of the three 350 hp 12 cylinder engines and main mud pump. In the background is the auxiliary mud pump and engine, mud hut and water tank. Main drawworks engines are fitted with torque converters.

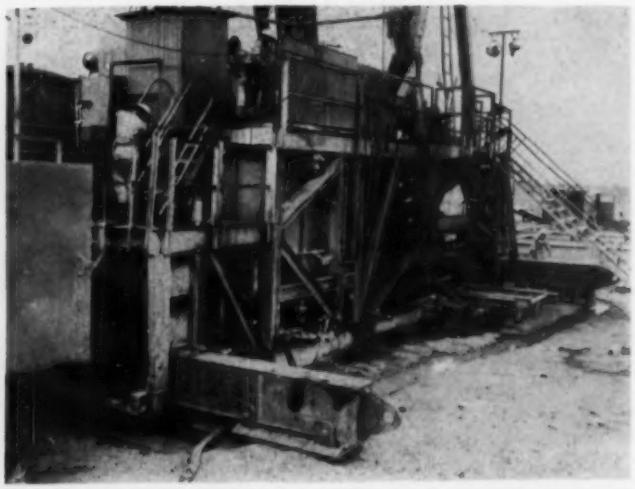


7. **Torque tube,** rather than v-belt drive, connects mud pump to engine compound. The torque tube extends from power take-off through the outrigger saddle bearing to the pump compound. Two universal joints are employed in this tube so that pump need not be in perfect alignment with the compound. Mud pump has a small rotary pump, mounted on the same skid, to supercharge pump section.

7000 ft of tubing is a normal run for the combination drilling and completion rig. Note the brace half way up that keeps tubing from bellying out.



8. **Blowout equipment** is mounted on rollers that rest on rails. Rail at the left is slid back beside the Christmas tree and matched with the front rail to make a track for the equipment.



9. **Cross members** extending through the substructure base are used when the rig is skidded upright by means of Athey tracks. Skidding is done after the drawworks trailer has been taken from the substructure.

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●

Hinson, Florida
(clay mine and processing plant)

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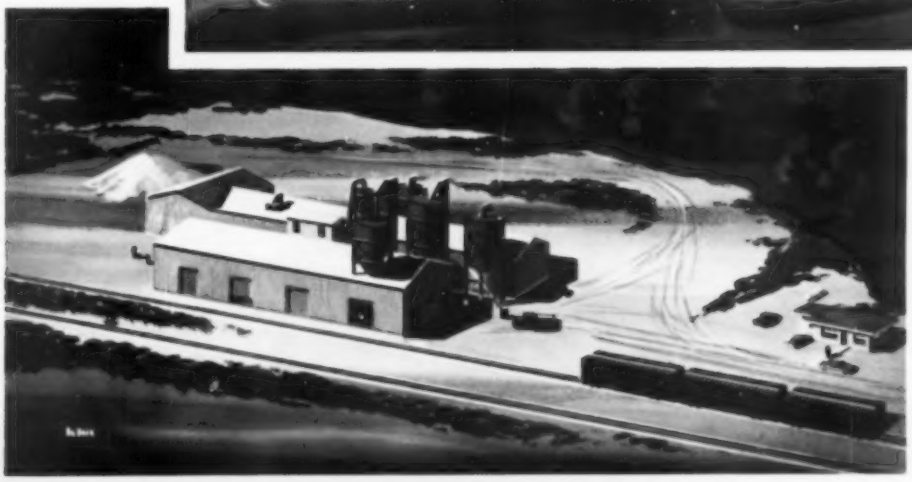
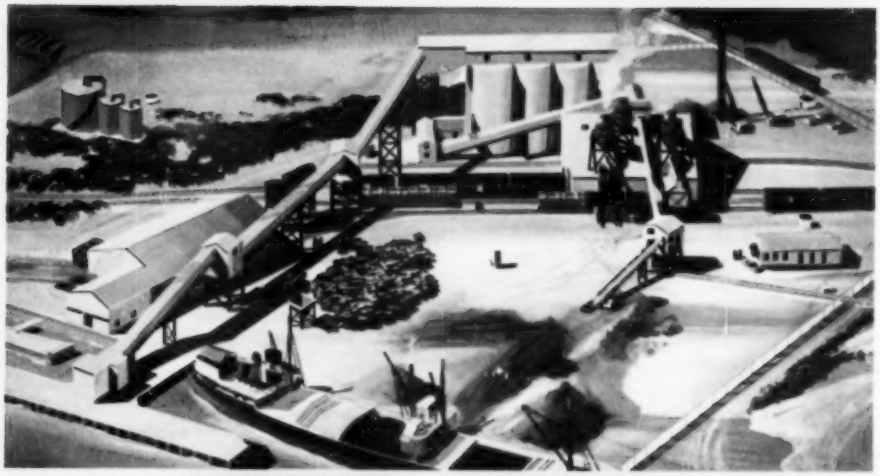
Brownsville, Texas
(barite processing plant)





Houston, Texas
(processing plant)

●

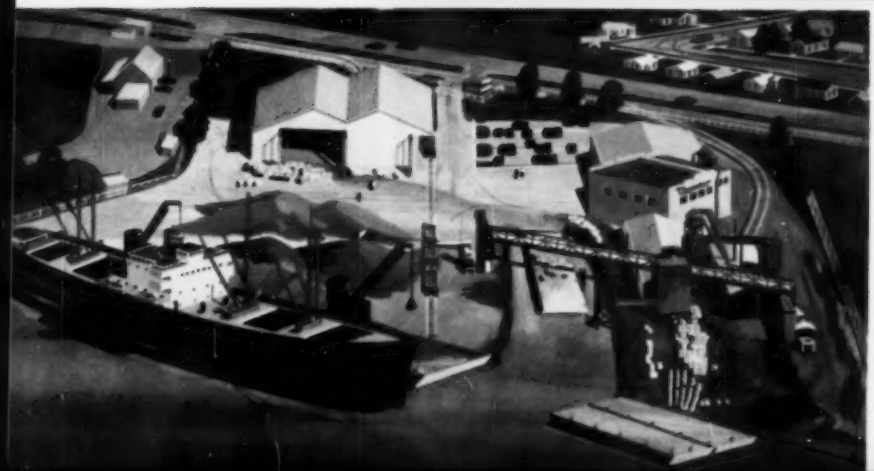
Lake Charles, La.
(barite processing plant)

●

Greybull, Wyoming
(bentonite mine and processing plant)

●

New Orleans, La.
(barite processing plant)



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Litho in U.S.A.

Keel is Laid for 'Loyd Noble S-66' Newest Drilling Barge for Calco Service

New Barge, largest for Calco, to operate in deep gulf area.

Another immense offshore drilling structure has left the drawingboards and is now under construction at Avondale, Louisiana.

This new addition is the "Loyd Noble S-66," a special type elevated deck drilling barge, being built for the Noble Barge Company. It is to be used by The California Company for drilling in waters of up to 100 ft depth in the Gulf of Mexico. The actual keel laying, marked by brief ceremonies, took place at Avondale Marine Ways June 1, following a series of strength and load tests performed on different units of the structure.

Following closely in the wake of the S-55, completed in the same yard for Calco just a year ago, the S-66 will be even larger.

According to Calco engineers, the height — even from the bottom of the spuds some 100 ft below the surface of the mud when in operating position, to the top of the two-well derrick—is about the equivalent of a 36-story building. The barge proper measures 217½ ft in length overall by 100 ft beam by 14 ft depth.

Structure of the S-66 will consist of a main barge hull and a watertight pontoon which, when afloat, houses under the barge. The main barge will be raised aloft at well location after the pontoon has been lowered to the very bottom by means of a system of hydraulically operated jacks. The main barge will provide air conditioned quarters for a 44 man crew as well as space for derrick, equipment and accessories.

An unusual feature is the two elevator system. One will make it possible for a man to travel from the barge deck down to the pontoons at mud level, a distance of nearly 200 ft. Another will travel inside the columns (12 ft in diameter and rolled from steel plate 2-in. thick), from the top of the column to the spud shoes below the mud surface.

16 S's

These Standard "S" Assemblies Are Used for These Otis Sub-Surface Controls	Locking Assembly	Locator Assembly	Equalizing Valve	Conc. X-O Assembly	Bean Cage	Sub	Ring Check Assembly	Combination Adapter	Pack. Man. Sub-Assy.	Side Port Adapter	Sep. Tool Eq. Valve	Spacer Sub	Side Port Comb. Adpt.
1 Cross-Over Choke	S	S	S	S	S								
2 Regular Flow Choke	S	S	S		S			S	S				
3 Dual Side-Door Choke	S	S	S		S			S	S				
4 Dual Separation Tool	S	S						S	S	S	S		
5 By-Pass Side-Door Choke	S	S	S		S				S				
6 By-Pass Separation Tool	S	S							S		S	S	
7 Side-Door Choke	S	S	S		S				S				
8 Separation Tool	S	S							S	S	S		
9 Lower Zone Acidizing Tool	S	S	S		S			S	S				S
10 Upper Zone Acidizing Tool	S	S						S	S	S	S		S
11 Circulating Tool	S	S	S					S	S		S		S
12 Side Port Nipple Choke	S	S	S		S	S			S				
13 S-P Nip. Separation Tool	S	S				S			S	S	S		
14 Plug Choke	S	S									S		
15 Lower Zone / Upper Zone — Ring Check / Acidizing Tool	S	S	S		S		S		S				S
16 Upper Zone — Acidizing Tool	S	S					S		S	S	S		S

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Sixteen Different Dual-Completion Tools— All Standardized on Otis "S" Dimensions

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EXPLORATION ACTIVITIES

BOLIVIA

★ Four U. S. oil and gas companies have obtained an option from the Bolivian Government covering the approximately 900,000-acre concession formerly held by Glenn McCarthy. The four are Tennessee Gas Transmission Company, Union Oil and Gas Corporation of Louisiana, and Lion Oil division of Monsanto Chemical Company, all of Houston, and Murphy Corporation of El Dorado, Arkansas. The same four firms also have entered into a contingent contract with McCarthy individually, and with Glenn McCarthy, Inc., a Delaware corporation, and Glenn McCarthy de Bolivia S. A., to purchase all the equipment they had in Bolivia, plus an assignment of all rights or claims in the old McCarthy concession. Tennessee Gas, which will own 35 percent interest in the concession, will be the operator for the four companies, through its newly-formed subsidiary, Chaco Petroleum, S. A. This is the second venture of the four companies into South America. They previously obtained an interest in a concession in Lake Maracaibo, Venezuela.

COLOMBIA

★ Colombian Sun Oil Company has signed an agreement for half-interest in oil concessions in Colombia covering 302,330 hectares (750,000 acres). This is its second contract involving exploration concessions in Colombia in less than six months. Colombia Sun made the contract with Mobil Oil Company de Colombia and International Petroleum Ltd., original applicants for the concessions. Sun agreed to drill two exploratory wells to a depth of 9000 ft each for its one-half interest. Pure Oil Company of Colombia and United Carbon Company will join with Sun in fulfilling obligations agreed to in the contract. Concessions involved are in the Sinu Area of Colombia. There are eight of them, located in Loma Verde, La Ceiba, Santa Lucia, Arboletes, Nicocli, Martinica, Rio Mangle, and Caimar.

OKLAHOMA

★ British-American Oil Producing Company et al, Kreiger No. 1, in Stephens County, has substantially extended the productive limits of Oklahoma's deepest producing reservoir. The Kreiger No. 1 well is located three miles south of British-American's discovery well, Harrison No. 2, which, at the time of its completion more than a year ago, was the deepest producing well in Oklahoma. Three months ago the British-American et al, Reed No. 1 well, a one-mile northward extension of the Harrison No. 2, was successfully completed as the second Bromide producer. The Kreiger No. 1 well, now drilling below 15,672 ft, encountered the Bromide sand at 14,807 ft, some 200 ft structurally higher than the discovery well. On open-hole drillstem test from 14,807 to 14,918 ft, the Kreiger flowed at an average rate of 6.6 million cu ft of gas per day, and gaged 22.5 bbl of 54.6 deg condensate per hour. On a second open-hole drillstem test from 15,123 to 15,297 ft, the well flowed at an average rate of 5.7 million cu ft of gas per day. In one hour it gaged 34 bbl of condensate or approximately 143 bbl per million cu ft of gas. Shut-in pressures on both drillstem tests exceeded 9000 psi. The total net Bromide pay section in the Kreiger No. 1 well exceeds that encountered in the Harrison No. 2 discovery well. However, the operators plan to drill ahead to 17,000 ft or a depth sufficient to test other potential reservoirs in the Simpson series, such as the McLish and Oil Creek sands. Presence of production in these deeper Simpson sands would increase substantially the already very large gas and condensate reserves for this important Anadarko Basin discovery. Including the Kreiger No. 1 well, British-American and its partners have currently five wells drilling in the field.

NEW MEXICO

★ Reiter Foster Oil Corporation with the McRae Oil and Gas Corporation, Denver, Colorado, has begun joint spudding operations on a new well site located in the rapidly expanding Bisti oil area of San Juan County. The well will be the McRae-RFO No. 1 Magnolia-Federal. McRae will use its personnel and tools in this Bisti operation.

UTAH

★ Cataract Mining Corporation has signed a farmout agreement with Gulf Oil Corporation to drill a deep-test well in the Vega Creek prospect of the Paradox Basin in Southeast Utah. The drilling will offset a large block of leases and royalties which Cataract holds jointly with Producers Uranium Company in that locality. The well was spudded in about July 1, 1957, and the exact location will be announced by Gulf.

LOUISIANA

★ Texaco's State Lease 2856, No. 1A, a wildcat on the northwest flank of Caillou Island field, Terrebonne Parish, was drilled to 18,060 ft and perforated at 15,438-68 ft and completed as a field extender. On a two-hour gage at that interval, it flowed at the daily rate of 142 bbl of 35.7 deg oil through a ¼-in. choke with 375 psi of tubing pressure. Nearest production was reported a mile and quarter east.

TEXAS

★ Southern Union Gas Company, operating out of Dallas, recently announced completion of a new flowing oil discovery about 10 miles east of the town of Alvord in Wise County. The company's Joe Rogers No. 1, according to exploration manager A. M. Wiederkehr, has been gaged flowing 216 bbl of 41 deg oil in 24 hours through 18/64-in. choke. Production is coming from perforations at 6542-52 ft in the Atoka conglomerate, with well showing gas-oil ratio of 733 to 1 and tubing pressure reading of 171 psi. The company's new discovery was drilled to a total depth of 6786 ft and cased with 5½-in. oil string to 6611 ft for completion. Well is about 2¾ miles east of oil production in the Black Creek field and 1¼ miles north of gas production in the Decatur North field.

★ Parker Petroleum Company, Inc. of Ponca City, Oklahoma, has spudded the Ben Hill No. 1-A well on its 2560 acre block in Roberts County. It will be carried to a depth of 11,000 ft to be completed in the Morrow formation, a prolific oil and gas producing zone in the Texas and Oklahoma Panhandle fields. The Hill No. 1-A will replace the discovery well, Ben Hill No. 1, now plugged and cemented because of mechanical problems that arose from the high pressures encountered while drilling at 10,954 ft in the Upper Morrow sands. For over four months the original well defied all attempts to complete it. Its name is now well known as one of the best gas and distillate discoveries of the Panhandle area. The Hill No. 1-A is located 660 ft northeast of the discovery well.

★ Sun Oil Company has just completed the No. 1 Parsell, a direct westerly offset, 1740 ft from the Parker discovery well, (Ben Hill No. 1) triggering a boom for this northeastern corner of Roberts County. The Parsell well is now testing gas and condensate.

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for total recovery

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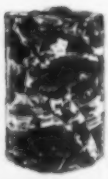
Currently, Core Lab is the *only* service company operating this specialized equipment on a commercial basis. Its availability emphatically accents the advantages of maintaining a full scope of integrated reservoir engineering services. Its use represents the coordination of three Core Lab departments—*Research and Development, Reservoir Fluids,* and *Engineering and Consulting.*

Again—experience, stability, and the investment of success back into research have created another opportunity for Core Lab to provide the entire industry with the benefits of a major development in recovery techniques.



Core Lab is now distributing complimentary copies of AAPG's new 36-page publication — Sample and Core Repositories of The United States, Alaska, and Canada. Send request on your company letterhead to address below. Please mention this publication.

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1957-58 officers of the Pacific Coast District, American Institute Division of Production, have been elected. Shown here are officers: (front row) C. R. Ball, Ball & Black Supply, treasurer; Mrs. Elsie M. Edmiston, API secretary; George L. Laurent, Standard Oil Company of California, Western Operations, Inc., district chairman; (back row) D. S. Hare of Monterey Oil Company, vice chairman for Los Angeles Basin; T. H. Acres of Sunray Mid-Continent, vice chairman of the advisory committee; Graham Lester of Union of California, vice chairman of the Coastal area; H. M. Van Clief of Honolulu Oil, vice chairman of San Joaquin Valley; Don Hall of McCullough Tool, assistant treasurer. Not pictured are Paul Andrews of Signal Oil and Gas, advisory committee chairman, and T. W. Patten of Standard of California, Western Operations, Inc., vice chairman for Coalinga-Kettleman.

Drilling superintendents agree: for fast delivery you can't beat Worthington QD (Quick Detachable) sheaves—the original two-piece design.
MV.7.2
WORTHINGTON CORPORATION, Oil City, Pennsylvania

PAKISTAN

★ Pakistan Sun Oil Company, wholly-owned subsidiary of Sun Oil Company, has signed agreements with the Government of Pakistan for oil exploration rights on 10,000 sq miles. Under the contract, the Pakistan Government will share with Pakistan Sun Oil Company the initial exploratory and development expenses to an extent of 25 percent. The acreage, representing the maximum available under the laws of Pakistan, is divided into five concessions, all located in the southern and southwestern portions of West Pakistan.

KANSAS

★ Great Basins Petroleum Company of Denver and Los Angeles has made location for the No. 1 Huff in Decatur County. The test, a step-out attempt, is a mile southwest of production in the Warner field which was discovered by Cities Service a year ago.

PANAMA

★ Cataract Mining Corporation of New York has completed its explorations for oil and gas in Panama. As a result of aerial photogeologic and seismic work, Cataract's exploration team in the Province of Chiriqui had identified at least fourteen structures sufficiently interesting to warrant drilling.

CUBA

★ Consolidated Cuban Petroleum Corporation's Escambray No. 1 well has proved one of the most difficult ever drilled in Cuba according to Clarence W. Moore, president of Consolidated. The test, located about four kilometers southeast of Santa Clara, was spudded on December 14, 1956; since then it has used 88 bits to drill 4110 ft for an average penetration rate of 46½ ft per bit. The well site was selected on the basis of geophysical and surface geology work done by Cuban Gulf Oil Company. Consolidated and independent driller C. J. Simpson are drilling the well on a farmout from Cuban Gulf Oil Company. The test, projected to 8000 ft, will give Consolidated a 50 percent working interest in a 10,000 hectare block of the Gulf properties in Las Villas province. Consolidated also has a two percent royalty on about 900,000 acres of Gulf concessions in Las Villas. There have been no oil or gas shows reported to date. The formation encountered was serpentine from 0 to 900 ft and serpentine and metamorphics from 900 to 4110 ft. The unusually hard nature of the formation, combined with some deviation in the hole, has resulted in a penetration rate of only 34.5 ft per day.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Tennessee Gas Shifts Operations, Relocates Offices Westward

Changes in the administration of oil and gas production operations by Tennessee Gas Transmission Company in North and West Texas and New Mexico have been announced by S. C. Oliphant, company vice president.

The company's central division headquarters have been moved to Midland, Texas, from Fort Worth, and district production offices will be established in Odessa, Texas, and Hobbs, New Mexico. The company's Wichita Falls production district, however, will retain its headquarters at Wichita Falls, Texas.

Changes are the result of expanding activities by Tennessee Gas in the area covered by its central production division, Oliphant said. Its operations have been intensified particularly in the West Eidson area of Lea County, New Mexico, where the company now has three producers and is drilling four additional wells on leases totaling 2720 acres. The discovery well in this area was completed at 413 bbl of oil per day, flowing on 28/64-in. choke, while a confirmation well flowed at the rate of 534 bbl per day on 16/64-in. choke.

Coincident with the transfer of the central division headquarters, J. P. Schmalz has been named division production superintendent. Schmalz, who has been in charge of the company's Midland district office, succeeds O. W. Ward, recently appointed vice president of the Canadian division of the Tennessee Gas production department.

D. P. Dampf, formerly operations assistant in the Midland district office, has been named superintendent of the new Hobbs district and J. D. Hicks, formerly area superintendent for the company at Monahans, Texas, has been appointed district superintendent at Odessa.

Editors of
THE PETROLEUM ENGINEER
have compiled a wealth of equipment information from the nation's top manufacturers for the 1957

EQUIPMENT REFERENCE ISSUE

July 15

Don't Miss It!

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

What's doing in DRILLING

★ **Deepest test** ever drilled in the Panhandle field of northwestern Texas has been plugged back and completed as a gasser. Magnolia Petroleum Company's No. 1 D. D. Feldman, 10 miles east of Glazier, Hemphill County, was drilled to a total depth of 16,002 ft and 5½-in. casing was cemented at 15,997 ft. Completion was in the Lower Tonkawa at a plugged back depth of 7700 ft. On test, this formation yielded 8,000,000 cu ft of gas per day and 36 bbl of condensate per million feet of gas.

★ **Colorado's drilling depth record** has been broken by Phillips Petroleum Company at its No. 1 Mannel in Rio Blanco County. The test is still drilling below a record depth of 15,368 ft and is scheduled to drill to about 17,000 ft into the Weber sand.

★ **Drilling contractors of the Four Corners** and San Juan Basin have organized the nineteenth chapter of the American Association of Oilwell Drilling Contractors. Known as the Farmington Regional Chapter, the group will be chairmanned by J. M. Riddle, Moran Brothers, Inc. Robert E. Jackson, Empire States Drilling Corporation has been elected vice chairman. Sixteen contractors attended the first meeting.

"Most muscular style show in history" was presented at the twelfth annual Drilling Industry Safety Clinic, sponsored by the American Association of Oilwell Drilling Contractors recently. Ten oil men took part in the parade of safety wearing apparel, before an audience of more than 150 drilling contractor, oil company, and supplier representatives meeting in Dallas. Pictured above is Bob Higginbotham, Kerr-McGee Oil Industries, Morgan City, Louisiana, modeling a winter suit of insulated nylon.

★ **Baker-Munday Drilling Company** interest formerly held by A. G. Munday has been acquired by L. W. Baker. Baker, in turn, has dissolved the old company and joined Schoenfeld-Hunter-Kitch Drilling Company of Tulsa, Oklahoma. The firm operates primarily in West Texas and southeast New Mexico.

★ **Merger of Trans-Tex Drilling Company** into Rimrock Tidelands, to operate as Rimrock Tidelands, Inc., is now complete. The new organization will operate six offshore rigs, two inland barges, and four land drilling rigs in the Gulf Coast area. Executive headquarters have been established at Shreveport, Louisiana, and exploration and drilling offices are in New Orleans.

★ **Kellogg Overseas Corporation,** a wholly owned subsidiary of K. L. Kellogg & Sons, has been organized for contract drilling outside the United States. K. L. Kellogg is president and R. C. Sharp, formerly vice president and director of Drilling and Exploration Company of Delaware, Inc., has joined the new company as vice president. Offices will be maintained in Compton, California.

★ **"Chief Roughneck for 1957"** title has been given to Arch Rowan, Fort Worth, Texas, drilling contractor. The award is made annually by the Texas Independent Producers and Royalty Owners Association to a former roughneck who has "rendered rough and rugged service in the field and has achieved a place of honor in the industry."

★ **Lifting of all road bans** in Alberta and other parts of Western Canada have given rise to a new spurt of drilling activity. In mid-June, there were 234 rigs running in western Canada. Largest concentration was in the eastern part of Saskatchewan and in central Alberta, with about 70 rigs active in each of these two areas. This is the highest rig count in western Canada since the week of March 18.

★ **Rig 16, Phillips Petroleum Company's** Mid-Continent drilling tool division has set one of the most remarkable safety records in the drilling industry. The crew of Rig 16 has worked 11 years with only one disabling injury — and that of a minor nature. It has completed the second 250,000 injury-free man-hour accumulation in its history. The other six rigs in the same Phillips' division are not far behind Rig 16, having completed injury-free records extending from one to five years. The 110 drilling division employees, who operate seven rotary rigs in Oklahoma, Colorado, and northern Texas, on June 1 completed a year without a disabling injury, consisting of more than 310,000 injury-free man-hours of work.

Replica of the Marsh funnel recently was presented to its inventor, H. N. Marsh, center, of General Petroleum Corporation, by Fred Chisholm, left, manager, technical service, Magcobar Corporation, Houston, on the occasion of the first modification of the funnel since Marsh invented it 25 years ago. Marsh is manager of the production engineering and equipment section of General Petroleum. At right is W. R. Kelley, senior drilling engineer, General Petroleum Corporation. Among the improvements in the modified funnel are that it is made of plastic, won't rust or bend, and mud engineers won't run the risk of burning their hands when testing mud from hot wells.

★ **"Why drill so many offshore wells"** John Hussey, Louisiana conservation commissioner, may be expected to ask soon, if buyers of Louisiana can't provide markets for the state's production. Hussey, long-time advocate of slower offshore development, recently stated that the state's per-well allowable "has just about reached its practical downward limit" after an almost steady descent since March 1953. "At any rate," he says, "the vast amounts of money being allocated to South American exploration would indicate that something is wrong with the domestic picture. Everything seems to be slowing down in this country — even offshore drilling."

This new Drilling Building is just one of three new structures dedicated recently at Gulf Oil Corporation's research center in Harmarville, Pennsylvania. This building is used to eliminate "bugs" in experimental techniques and drilling tools before field testing. The research center now encompasses 44 buildings on 53 acres, and deals with every phase of petroleum science.

Rotary Rigs Operating in Oil Fields of United States and Canada*

	May 20	May 27	June 3	June 10
Alabama	13	11	10	10
Arkansas	25	32	24	20
Arizona	0	0	0	0
California	91	93	97	96
Colorado	42	42	42	45
Florida	1	1	1	1
Georgia	0	0	0	0
Idaho	0	0	0	0
Illinois	63	39	40	58
Indiana	9	7	4	6
Iowa	2	2	2	2
Kansas	152	150	149	160
Kentucky	9	9	7	10
North Louisiana	46	56	54	56
South Louisiana—Land	278	280	286	273
South Louisiana—Offshore	106	101	98	101
Total Louisiana	430	437	438	430
Maryland	0	0	0	0
Michigan	13	9	10	11
Missouri	1	1	1	1
Montana	31	34	32	29
Mississippi	31	29	32	37
Nebraska	33	38	40	35
Nevada	0	0	0	0
New Mexico	137	138	143	138
New York	1	1	1	0
North Dakota	21	22	24	25
Ohio	1	1	1	1
Oklahoma	233	210	232	218
Oregon	1	1	1	1
Pennsylvania	15	15	15	15
South Carolina	0	0	0	0
South Dakota	2	2	2	2
Tennessee	0	0	0	0
Texas Gulf Coast—Land	203	206	191	199
Texas Gulf Coast—Offshore	4	5	4	4
West Texas	367	373	371	373
North Texas	302	312	313	295
East Texas	45	53	65	57
Total Texas	921	949	944	928
Utah	34	42	44	42
Washington	0	0	0	0
West Virginia	1	1	0	2
Wyoming	66	68	75	75
Total United States	2379	2384	2411	2398
Western Canada	181	202	222	234
Eastern Canada	1	1	1	1
Grand Total	2561	2587	2634	2633

*As reported to the American Association of Oilwell Drilling Contractors by Hughes Tool Company.

★ **A deep nineteenth hole** (and three others) for the exclusive Los Angeles (California) Country Club may be expected soon. Club members have agreed to open their 300 acres to the drill for oil and gas development; they have organized a new company called Westla Company to handle details and select the four drill sites. Drilling bids are being invited on a formula calling for a $150,000 cash bonus, a flat 32 percent royalty plus a percentage of oil company or operator profits after all operating and development costs. Bids are to be opened July 10.

★ **Deepest hole in West Texas** has been re-entered by Parker Drilling Company under a Gulf Oil Corporation contract. Well is the No. 1-A Northup in Reeves County, 23 miles of the city of Pecos. In 1953 the well was drilled to a total depth of 16,696 ft, deepened in 1954 to 18,609 ft and later that year was deepened again to its present depth of 18,709 ft. Parker is testing a gas show at 18,417-709 ft found in the last re-entry. Deepest well in Texas is in Jackson County, South Texas; it is Magnolia Petroleum Company's No. 418-A West Ranch, D&A at 20,060 ft.

★ **Karper and Glass Drilling Company,** Graham, Texas, has been selected as the name of the former Rankin, Karper and Glass organization. Ben H. Rankin, a partner in the firm died recently. Karper and Glass operate four rotaries in the North Central Texas area.

★ **A valid investment** into the future of the drilling industry has been made through allocation of $10,000 in education grants by the AAODC board of directors. The amount will go to finance the association's grant-in-aid program to the Petroleum Extension Service of the University of Texas ($5000), added funds for the writing of a new college-level drilling textbook ($1000), and allocations for training films and the School of Drilling Technology. AAODC has been quick to realize the need for "up-grading" drilling personnel for tomorrow's operations. Time has past for contractors and men who know only the value of "good iron." New "required subjects" for successful business these days might well be cost accounting, business law, tax accounting, personnel and public relations.

★ **Southeastern Turkey bound rig** is on its way, after assembly in Houston, Texas. Tidewater Oil Company, as operator, will pick up the tab of a "conservative $2,000,000" to buy and ship the 4000 tons of equipment to its location. The 15,000 ft rig has been fitted out by some 200 suppliers. Entire shipment, that would be the equivalent of 100 train carloads, includes 1400 tons of tubular goods, 1500 tons of mud, cement and chemicals, 17 vehicles of transportation (including an airplane), eight house trailers, 20 prefab buildings, 13 miles of aluminum water line and enough food for three months. Rig was expected to leave Houston in mid-June. First location is near Madrin, 350 miles inland into Turkey, and will be the first well on a 3,000,000 acre concession. Tidewater is associated in the project with Seaboard and Atlantic Oil companies.

★ **Outstanding drilling safety award** was presented to W. P. Woods, toolpusher for Oil Production Maintenance, Inc., Houston, Texas, at the twelfth annual Drilling Industry Safety Clinic in Dallas. The special honor was for "no reportable medical injury, no lost time, and no down time." The record was achieved by Woods, and the three drillers and their crews under his supervision, for a full calendar year of accident-free operations. Presentation was made to Woods by the American Association of Oilwell Drilling Contractors safety committee.

★ **About 6000 wells** will be drilled in Kansas this year, calculates the state conservation division. The estimate is based on tabulation of drilling intentions filed with the division. The year's total until June 1 was 2480, with 531 filed during the month of May. Normal or near normal activity for the rest of the year would boost the monthly average above the 500 mark, officials say.

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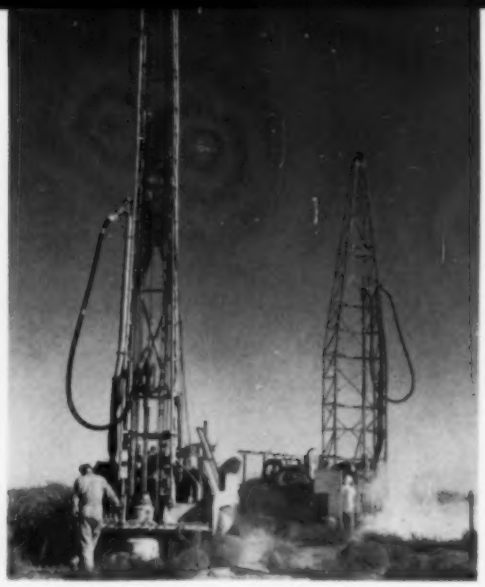

Shot hole drilling methods for seismographic surveys have changed much in the short life of Humble Oil & Refining Company. Hand auger crews performed the task of drilling holes in the mid-thirties (above). Power-driven and truck-mounted units perform the same task today (right). These advances, coupled with advent of new highly sensitive instruments, yield greater accuracy and speed on Humble's widespread geophysical operations.

Humble's Fortieth Anniversary

FORTY years ago, Humble Oil & Refining Company came into corporate existence in Houston, Texas.

Although June is the company's official anniversary, the company began its operations on March 1, 1917, under a gentlemen's agreement among the principals. For three months and three weeks, until the charter was received on June 21, oral promises and individual integrity preserved a merger that involved $8 million in properties and a net daily production of some 8800 bbl of oil.

In a way, Humble Oil & Refining Company dates from Spindletop, for it was there that most of the men who later organized Humble met and became friends. W. S. Farish, who was one day to become chairman of the board of Standard Oil Company of New Jersey, came to Spindletop from Mississippi where he had practiced law. At the same time, R. L. Blaffer left New Orleans and his father's coal business to work in Beaumont for the railroad. He soon found himself in the oil business instead.

A third original incorporator of Humble, W. W. Fondren, started in the oil business at Corsicana with a drilling rig purchased from money saved when he worked there as a roustabout. He went to Humble, Texas, in 1906 when the field was discovered, and his equipment was part of the Humble Company when it was organized.

The Sterling family — Ross S. Sterling, Frank P. Sterling, and Miss Florence Sterling—organized the old Humble Oil Company, from which the present organization took its name. Another block of property came from the Wiess family of Beaumont, brought into the new company by H. C. Wiess, who took over the Wiess properties upon his father's death in 1912. Other holdings and properties which went into the merger were those of J. C. Wilson, Frank Ireland, Charles Goddard, L. A. Carlton, Ed Prather and Bert Broday — along with the Schulz Oil Company, owned principally by Blaffer and Farish.

An Integrated Company

As an integrated company Humble started out with most of the necessary facilities . . . but nothing fancy.

There was one "washpot" refinery at Humble, Texas, which processed 300 gal of gasoline a day from oil out of a single well. The marketing division, a model T truck, picked up each day's product at the refinery and hauled it into Houston for sale to "filling stations." There was a pipeline — three miles of gathering line in the Goose Creek field.

Always Emphasis on Production

Until March of the following year the company had no geologists. This was not unusual. Petroleum geologists were a new and rare breed then. But there was a land department, established a few months after the company was founded.

The company's emphasis was on production, and by 1918 Humble moved up into third place among Texas producers.

Before the end of 1919, occurred probably the most important single financial event in the history of Humble. Doubling the number of its shares of stock, Humble sold 50 percent of the stock to Standard Oil Company of New Jersey. This gave Humble a vital market outlet, and it gave Jersey a source of crude and products.

Improved exploration and production techniques and the company's attention to production led Humble up the ladder in the early 1920's, until 1925 when Humble found itself the second largest producer east of the Rockies with a net production of 18 million bbl.

Largest Producer

In 1943, Humble achieved a position it has held ever since — America's largest domestic producer of crude oil. After World War II, production dipped briefly, but by 1948 it had surpassed the wartime daily record and stood at 368,000 bbl. Last year for the first time this figure was exceeded, as 1956 production hit 371,000 bbl.

Also since World War II, Humble has moved into first place in gasoline sales in Texas, a position it has held since 1951.

Although the bulk of Humble's producing operations are in Texas, exploration and producing activities have been expanded broadly in the past several years. Humble's first offshore well was brought in off Grand Isle, Louisiana, in 1948. Production in Mississippi dates from 1944 and in 1943 Humble completed the first producing oil well in Florida.

Another first was Humble's Navajo Reservation No. 1 completed in 1955 as the first commercial producer in Arizona. The company has had production in California since 1949 and is doing exploration work in Washington and Oregon. The most recent and farflung operation is a well soon to be drilled in Cold Bay, Alaska. ★ ★ ★

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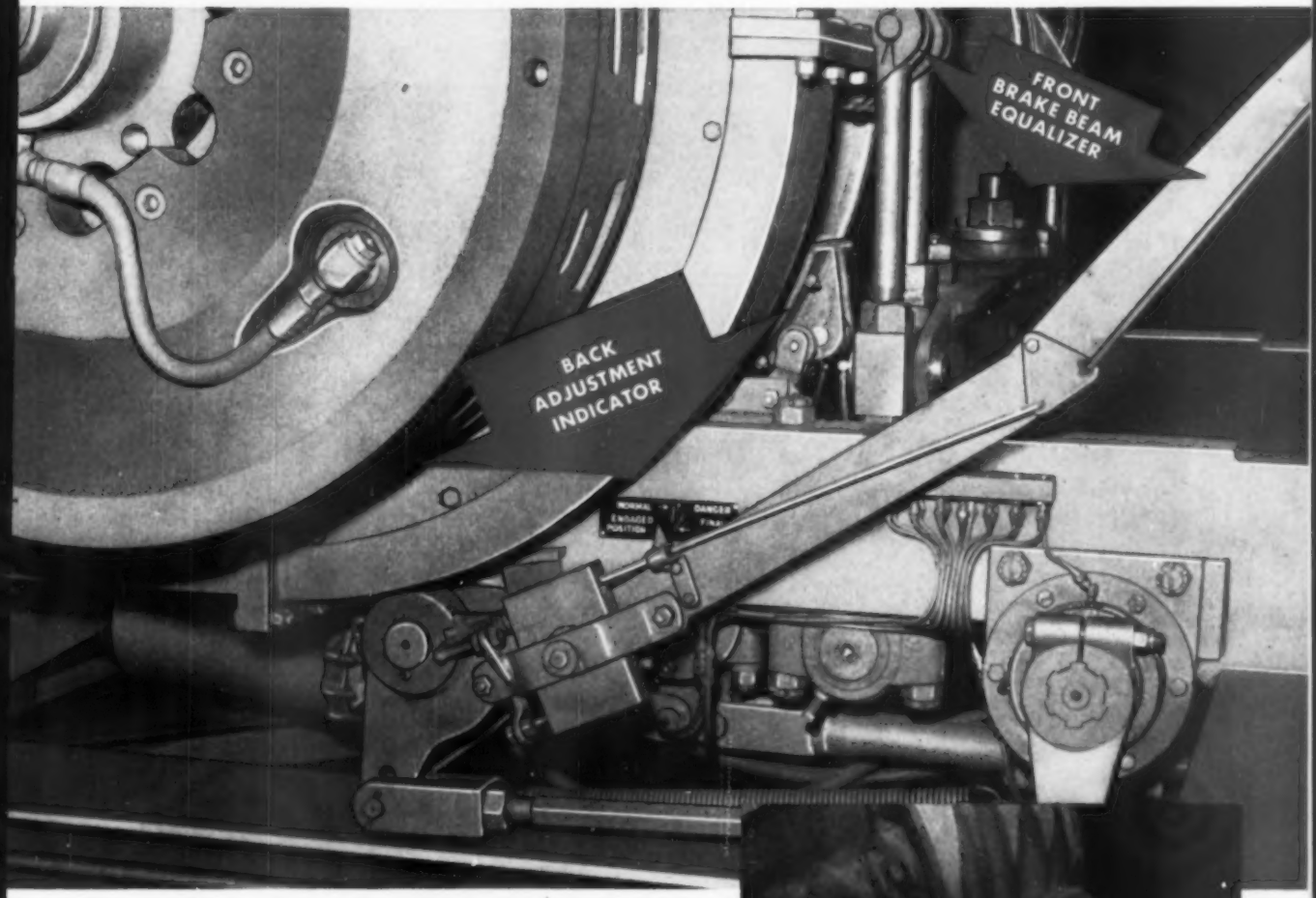

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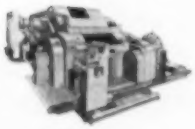

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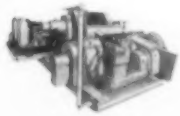
9,000 Ft.—4½" Drill Pipe
11,000 Ft.—3½" Drill Pipe



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8,500 Ft.—3½" Drill Pipe

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Mission Pistons feature rubbers with a fabric backing that assures long, leak-free service. Once a leak starts, however, the fabric back fails and causes a quick pressure drop which warns the driller to stop the pump before liner damage can occur. Mission Pistons are dependable and economical. When you remember

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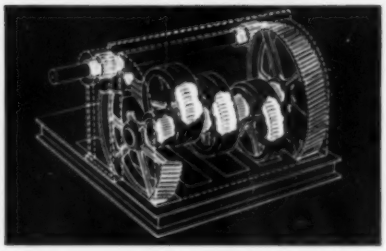

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THE OASIS—

A gathering spot for NOMADS

Nomads Meeting Dates and Secretaries

New York Chapter, first Monday of the month, Hotel Roosevelt, New York. Executive Secretary, E. W. Hoeppner, in care of Hughes Tool Co., Room 903, 45 Rockefeller Plaza, New York 20, N. Y.

Houston Chapter, second Monday. Ye Old College Inn, Houston, Texas. Executive Secretary, Harry E. Estes, P. O. Box 18171, Houston 23, Texas.

Los Angeles Chapter, second Wednesday, Jonathan Club, Los Angeles, California. Executive Secretary, W. A. Sawdon, P. O. ox 848, Hollywood 28, Calif.

Tulsa Chapter, third Friday, Mayo Hotel. Executive Secretary, E. L. Thomas, P. O. Box 3771, Tulsa 9, Okla.

Dallas-Fort Worth Chapter, first or second Monday. Secretary, R. B. Gilmore, DeGolyer & MacNaughton, 5625 Daniels, Dallas, Texas.

Leaders of Nomads and two Tulsa organizations are shown with Dr. Guillermo Zuloaga, director of Creole Petroleum Corporation, who recently addressed a joint meeting of the groups. They are presidents W. M. Erdahl, Tulsa Geophysical Society; Dr. Frank J. Gardner, Tulsa Geological Society; Dr. Zuloaga, and Guy Williams, Tulsa Nomads chapter.

Houston Nomads had these guests at June 10 meeting: (standing) Gen. W. P. Lee, commanding officer, Amarillo AFB; Martin Newell, Tidewater; A. E. Albiston, Brown Drilling; Walter Leabo, International Oil; (seated) B. G. Frazier, International Oil; A. J. Rowan, International Drilling; and W. H. Mannon, Camdrill.

Speaker at the May meeting of Los Angeles Nomads was William Nichols, Los Angeles Coliseum manager. Guests were: (standing) J. H. Romijn, BPM; E. O. Hammer, Texaco; G. L. Linder, National Supply; Rhett Wilder, Baker Transworld; "Rosey" Hendershott, Caltex; H. B. White, Caltex; (seated) W. N. Thompson, Drilexco; R. A. Hancock, Petro-Tech Service; Nichols, the speaker; Charles Looper, Ralph Parsons; and Pete Marolf, IPC.

RUNNING TOUR with MEN in the INDUSTRY

James A. Perkins Jr. and **Julian W. Quinn** announce the formation of the firm of Perkins and Quinn Petroleum Engineering Consultants with offices in Houston, Texas.

J. A. Perkins Jr.

J. W. Quinn

Both Perkins and Quinn have had 23 years' experience in petroleum engineering with the Houston division of the Gulf Oil Corporation where Quinn was chief of the reserves group and Perkins division reservoir engineer.

Dick Girouard has joined the staff of Wm. Ross Cabeen & Associates and will become Rocky Mountain division land manager. He was formerly in charge of the Billings land department of Honolulu Oil Company. He will replace **Tom Moran,** who with **Dick Mead,** also of the Denver Cabeen office, will shortly open the new Calgary offices of Wm. Ross Cabeen.

Bill Hudson, formerly petroleum engineer with Lion Oil Company at Fort Morgan, Louisiana, has joined Cabeen Exploration Corporation at Denver as district production superintendent.

I. W. Rogers has resigned as drilling superintendent of Makin Drilling Company, Hobbs, New Mexico, and will devote full time to his duties as president of Hobbs Fishing Tool, Inc.

A. B. Brown has been elected to the presidency of Richmond Exploration Company. Richmond Exploration is a South American producing and exploration subsidiary of Standard Oil Company of California and operates in Venezuela. Brown succeeds **C. R. Cabrera** who was recently appointed to Standard's executive staff.

The appointment of executives for the D & D Drilling Company, wholly owned subsidiary of Falcon Seaboard Drilling Company, Tulsa, has been announced. **E. L. Walton** has been appointed general manager; **Mahlon A. Mundy,** drilling superintendent, and **Ernest Neipp** has been made office manager of the Falcon Seaboard subsidiary in Venezuela.

James E. Ubben has been appointed assistant director of the Division of Production, American Petroleum Institute. Ubben will be in charge of staff work on standardization of oil field equipment, succeeding **Edwin Joyce** who retired recently.

J. A. Vickers, president, The Vickers Petroleum Company, Inc., Wichita, has been commissioned by Governor George Docking to serve on the governor's Oil Advisory Committee for the state of Kansas.

Five new oil and gas exploration division headquarters in five strategically-located cities were announced by Tennessee Gas Transmission Company. Appointment of exploration managers to head the new divisions was announced also. Rocky Mountain, Denver—**R. L. Sielaff;** Mid-Continent, Oklahoma City—**J. W. Thompson;** West Texas-New Mexico, Midland—**R. C. Honea;** Gulf Coast, Houston—**A. N. McDowell,** and, Louisiana-Offshore, Lafayette — **F. B. Stein.** Each of the new division heads has been serving as a district exploration manager for the company.

James A. Haertlein has joined William J. Carey as geologist in Dallas. Haertlein was most recently chief geologist for Nortex Oil & Gas Corporation, Dallas, and was associated previously with Amerada Petroleum Corporation and Standard Oil Company (New Jersey).

J. A. Haertlein

F. W. Bartlett

Fred W. Bartlett was elected vice president in charge of producing, Socony Mobil Oil Company, Inc. He succeeds **John C. Case** who has retired. He served as a director and members of the executive committee of the Arabian American Oil Company from June 1953, to January 1956.

N. A. Rousselot will assume the duties of a special representative reporting to the executive vice president on all matters pertaining to the Seaboard Oil Company's joint operations in the Kettleman Hills, the Guijarral Hills, Pleasant Vally, and Coalinga Nose oil fields. He will have offices at Corona del Mar, California.

R. Bruce Myers, chief accountant for John W. Mecom, was recently elected president of the Houston chapter of the National Association of Cost Accountants. He is pictured, right, being presented with an engraved gavel by outgoing President Reidel H. Wilson, controller of the Wyatt Metal & Boiler Works, Inc., at the chapter's twenty-fifth anniversary celebration.

Lysle R. Kirk has been named chief geologist for the Ohio Fuel Gas Company replacing **Kenneth C. Cottingham,** who retired May 1. Kirk has been with Ohio Fuel 21 years. He started as a clerk in the gas engineering department of the Columbia Gas System Service Corporation here in 1936, and was transferred to Ohio Fuel as a junior geologist in the geological department the same year. He was promoted to geologist in 1940.

L. R. Kirk

Richard Steinhorst Jr., formerly field superintendent of the Colorado-Nebraska fields, with headquarters at Sterling, Colorado, was transferred to the newly established field offices in Lafayette, Louisiana, as field superintendent. This office was recently established as headquarters for Southern Louisiana and offshore operations. **G. H. Walkup** transferred as field superintendent from Pilot Butte field near Riverton, Wyoming, to replace Steinhorst. **Paul A. Kindsvater,** formerly assistant to the general production superintendent, with headquarters at Dallas, Texas, was appointed to replace Walkup.

Gulf Oil Corporation has named appointees to newly-created positions in its Fort Worth production division. **J. D. Moody** named to district manager of the new Midland district 5. He formerly was assistant division exploration manager in the Fort Worth offices. **K. E. Rotegard,** to manager, district 6; **J. A. Hord,** manager, district 7, and **E. Hosford,** manager, district 8.

E. Charles Patton, formerly in charge of reservoir engineering and related laboratory work for Magnolia Petroleum Company, has been named president of the newly-organized Reservoir Engineering Laboratories, Inc., with headquarters and laboratory facilities in Dallas, Texas. He helped organize and for 15 years supervised a laboratory for Magnolia.

E. C. Patton

E. D. Klinger

E. D. Klinger, chief geologist for the Lion Oil Division of Monsanto Chemical Company has elected early retirement, and is moving to Shreveport, Louisiana, where he will serve as a consultant. Klinger will offer consulting services involving: Evaluation of oil and gas properties; advice and recommandations on exploratory drilling in the Mid-Continent Permian Basin and Rocky Mountain Regions; appearance before regulatory bodies as an expert witness in hearings involving proration and other oil and gas matters; advice on development of producing properties; supervision of surface and subsurface exploratory programs, and geological supervision and interpretation of geophysical surveys.

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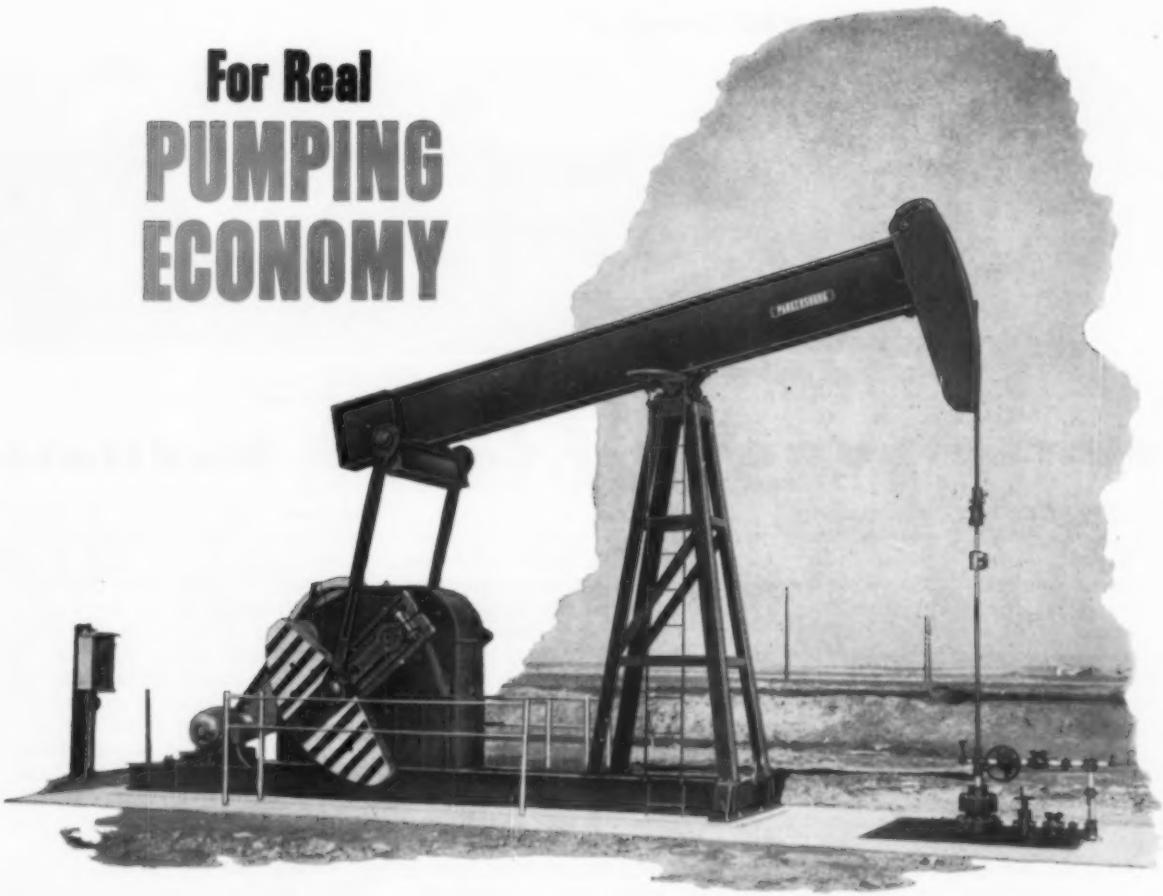

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The "David buggy"

The versatile water buggy literally pulls Gulf seismic parties through the South Texas mudflats. Here a Gulf surveyor takes a reading on the alidade beside his buggy and the cable barge.

WATER BUGGY For Coastal Mudflats

OVER water, through the mud or on dry land, Gulf Oil Corporation's new workhorses — David buggies — are keeping South Texas seismic exploration crews and equipment on the job.

Several of these new type marsh buggies are being used in the Laguna Madre area, near Padre Island, in South Texas by Gulf's Houston Exploration Division.

David buggies may not compare in appearance with the latest sports cars, but their versatility and mobility are making them a favorite of the seismic crews.

A Purpose for Every Piece

Frame of the buggy not only serves as a chassis but as a gasoline tank as well. Constructed from 4-in. pipe, it can withstand much abuse. The chassis is mounted on four large airplane tires that are studded with large rubber lugs. These lugs provide traction in muddy places or serve as paddle wheels in water. The buggy floats in three feet of water.

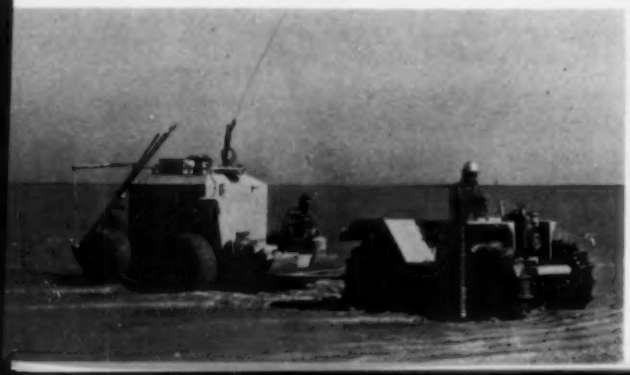
Power for the four-wheel drive buggies are developed by interchangeable two or four cylinder engines.

Uses for the vehicles are many. A seismic crew uses five buggies in normal operation. One pulls a small water barge carried along to supply water for jetting or drilling the shot holes at locations away from standing water. Another buggy pulls the recording instruments shack barge. Still another pulls the portable drilling rig barge. A fourth carries the cable barge. All this equipment is amphibious, rolling on smooth airplane tires in low water or dry land areas or floating in deeper water. A spare buggy, driven by the supplier's mechanic, moves along with the group as "insurance" against breakdowns. Should one occur, the spare buggy is placed in service and the mechanic, with his store of spare parts, does an on-the-spot repair job.

Acknowledgment

Photographs and description of the David buggies are presented through the courtesy of Gulf Oil Corporation.

Effective on water as much as on land — or in the mud, this buggy is pulling Party 9's recording instrument shack barge.



The buggy tows the shot hole rig to its location. This crew of Seismic Party 9 is working in the Laguna Madre area between Padre Island and the South Texas mainland near Port Isabel.

Rubber-lugged airplane tires of the water buggies serve many purposes. In the mud, they provide traction enough to free this temporarily trapped cable barge; in water lugs on the tires provide a paddle-wheel type motivation.

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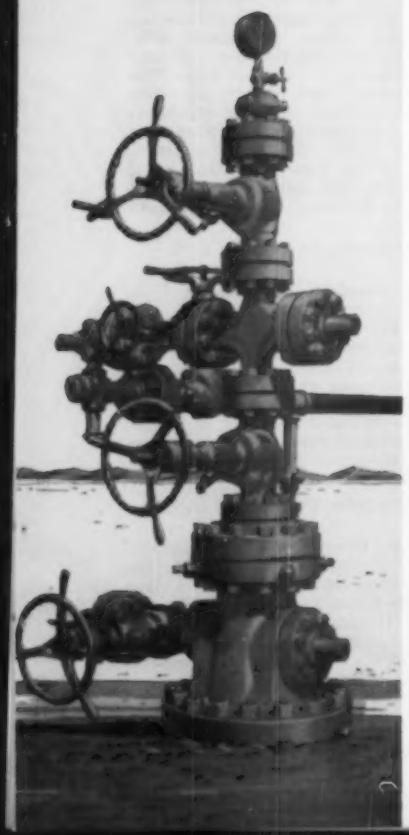

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NEW Drilling and Producing Equipment

First Bearings Wall Charts. The Norma-Hoffmann Bearings Corporation has shipped to distributors and manufacturers 2 wall charts, 20 by 27½ in., the only compiled series listings in chart form of ball and roller bearings as offered by the various manufacturers, thus relating their standard lines to that of competitors. These charts — titled "Ball Bearing Series Interchange" and "Cylindrical Roller Bearing Series Interchange" — will be followed by a third, based on the same general plan, "Decimal Equivalent Chart." Charts are printed on Texoprint, a plastic printing paper. *The Norma-Hoffmann Bearings Corporation.*

Circle number (1) on reply card.

24-Hour Time Switch. Completely automatic control of intermittently operated equipment of all types is provided by a new and versatile 24-hr time switch. It will handle as many as 48 "on" and 48 "off" operations in one day. A control dial, scaled in 15-minute graduations is used to set up a daily operating schedule. Running periods are set by sliding self-contained, non-removable trip levers in or out on the dial. The switch will repeat the entire schedule automatically each day. A calendar cutout device which will make the switch completely selective for all 7 days of the week is available as an accessory. *Zenith Electric Company.*

Circle number (2) on reply card.

Aluminum Foot Valve. A new heavy-duty aluminum foot valve with strainer, so light that it can be handled easily by one man, has been developed. It weighs 41 lb for the 8-in. pipe size, less than half as much as the traditional iron valve. The 6-in. pipe size valve weighs 19 lb. Valve has proved to be resistant to corrosion and mechanical damage. *Clayton Mark & Company.*

Circle number (3) on reply card.

Heavy Duty Trailers. New brochure on complete line of heavy-duty low-bed trailers has been released by Birmingham Mfg. Co. Included in the line, and illustrated in the book, are the company's oilfield trailers, made to customer specifications. Other models are also illustrated, and information and general specifications are listed. *Birmingham Manufacturing Company, Inc.*

Circle number (4) on reply card.

Slush Pumps. How to care for slush pump and fluid end parts is the title of a new 24-page pocket-sized booklet. It describes maintenance procedures that will prevent interruptions of operation and extend pump life. Care of each working part (piston rods, pistons, valves and seats, liners, and packing), assembly procedures, and proper pump operation are also described. *National Supply Company.*

Circle number (5) on reply card.

To Men of Progress

We shorted you on new equipment and literature in this issue . . . but will more than make it up to you in our special Equipment Reference Issue of July 15. This is a full issue devoted entirely to new equipment, tools, services, etc. — a highly successful idea started by THE PETROLEUM ENGINEER two years ago when the first equipment progress issue was published.

Recently we sent letters to all leading manufacturers and suppliers for the drilling and oil and gas production industries. We asked them for their most significant developments in new tools, products and services. In reply has come the most astounding lineup of short articles on these subjects ever assembled for publication.

Just a few of the articles covering drilling equipment include — a new super derrick for offshore drilling — a new instrument that records all drilling operational data — a simple rig engine modification that raises power 125 hp — a diamond bit that junk won't damage. In production, new perforating guns are being introduced — a new hydraulic pumping unit that mounts on the well head — a new ammonia absorption system for LTS. These are but a few of the new lines of equipment that will be discussed in this issue.

Stay on top of industry's newest developments! Be sure to read your Equipment Reference Issue to be published July 15.

James A. LeVelle
Engineering Editor

Full Lease Automation. Full lease automation from the wellhead to the pipeline is now available commercially through packaged lease automation systems. Fully automatic wellhead shut-in control, well test control, well flow control, tank switching, custody transfer, fluid metering and lease safety controls are all included in BS&B Phanto-Matic lease systems. The packaged automation program offers producers greater accuracy, elimination of routine manual procedures on the lease site, greater efficiency in all phases of lease operation and substantial savings on operating expenses.

BS&B lease automation component systems fall generally into two primary classifications — Phanto-Pumper systems and Phanto-Gager systems. *Black, Sivalls & Bryson, Inc.*

Circle number (6) on reply card.

Magnetic Clutch. A new 6-page bulletin entitled "The World's Finest Magnetic Clutch" has been published. The bulletin — Fawick No. M-101 — provides dimensional drawings and specifications on the Fawick Model SC magnetic clutch (stationary field type), Fawick Model SB magnetic brake (spring-engaged, electrically-released) and Fawick Model SBR magnetic brake (spring-engaged, electrically-released with rectifier). Size range (approximate) of Fawick magnetic clutches and brakes is from 2 to 13 in. *Fawick Airflex Division, Fawick Corporation.*

Circle number (7) on reply card.

Stabilizing Tools. An informative 16-page booklet has been issued describing the various applications of stabilizing tools. Included are descriptions and illustrations for the stiff bottom hole hook-up, the Pendulum type of hook-up, for avoiding sticking in deflected hole, for reducing drill string torque and their use as a fulcrum in deflected holes. One of the features of the booklet are tables listing the common types of stabilizers and their characteristics as well as their application under different formation, hole and string conditions. Booklet is entitled "The Use and Application of Drill Collar Stabilizers." *Grant Oil Tool Company.*

Circle number (8) on reply card.

Personnel Selection and Training. Tests and other materials for use in personnel selection and training are described in the 1957 Industrial Catalog issued by Science Research. Catalog contains materials to use in selecting employees, improving employee performance, and reducing turnover. Also included are tests of intelligence, interest, and personality, as well as tests for measuring aptitudes and skills. *Science Research Associates.*

Circle number (9) on reply card.

Worm Gear Drives. A new 16-page, illustrated bulletin, No. 145 — Finger Tip Facts on Cleveland Worm Gear Drives — provides summary information on the complete standard line of speed reducers, worm gear sets and special units manufactured. *The Cleveland Worm & Gear Company.*

Circle number (10) on reply card.

New Hose and Hose End Catalog. Publication of a new 40-page hose, hose ends and assemblies catalog is announced. Catalog gives information on bulk industrial hose, permanently attached hose assemblies, swaged hose assemblies and ends, hose-end swivel adapters, assembly instructions and installation data. "At-a-glance" charts are featured in the catalog for hose agent selection, hose specifications and hose end identification. Over 180 elements are shown on the agent selector chart. The bulk hose specifications include 24 Weatherhead industrial hoses with complete information as to ID and OD, maximum working pressure, proof-test pressure, minimum burst pressure, inner and outer tube materials, reinforcement, temperature range and types of hose ends. *The Weatherhead Company.*

Circle number (11) on reply card.

Screw End Venturi Type Valve. Catalog sheet illustrates and gives specifications and prices of new 2 by 1-in. Venturi type production valve with screw ends. Advantages of new screw end, forged steel, and stainless trim Venturi type valve include savings in cost, reduced weight and operating torque. *Orbit Valve Company.*

Circle number (12) on reply card.

Pile Hammer Leads. New bulletin contains information on the evolution and use of pile hammer leads, describes the basic lead types with their additions and variations, and presents precise tabular data on weights and specifications of leads and accessories. Bulletin 66 covers the following lead types: Swinging, underhung vertical, underhung 6 to 1 and 3 to 1 fore and aft batters, extended 4-way batter, and railroad pile driver leads; also the adaptation of hairpins, telescopes, and extensions above the boom point to these leads. Information on each item includes its use, types of pile for which used, exactly what types of jobs for which specific leads can and can't be used, and the advantages and disadvantages of specific equipment. Illustrations are included. *McKiernan-Terry Corporation.*

Circle number (13) on reply card.

New GM Hydrostarter. General Motors' new and improved Hydrostarter, which provides instant starts for diesel engines while eliminating the maintenance costs of batteries, cables, magnetos, air compressors, etc., is fully described in a new brochure. *Detroit Diesel Engine Division, General Motors Corporation.*

Circle number (14) on reply card.

Saran Lined Centrifugal Pumps. Availability of saran lined centrifugal pumps to provide completely corrosion resistant piping systems has been announced. New pumps permit the handling of a broad range of corrosive liquids. Two sizes available include 1½ by 1-in. and 3 by 2-in. pumps, lined completely with saran and equipped with mechanical rotary type seals. These special seals are designed to eliminate the high frictional heat failures and resultant leakage problems of packing glands. Seals are easily changeable for adapting the pump to the handling of various corrosive fluids. Both pumps are equipped with seal-cooling systems, and the cooling medium applied may be the fluid being pumped or water from an external source, either of which is channeled back through the pump. *The Dow Chemical Company.*

Circle number (15) on reply card.

Welding Head Manipulator. Air Reduction has demonstrated a new welding head manipulator and control console for longitudinal and circumferential welding. The unit was engineered for the purpose of universal positioning of a welding head and accurate variable speed traverse of the head. The manipulator, of all-welded construction, is especially designed for precision welding applications. Both Heliwelding (tungsten inert gas arcwelding) and Aircomatic® (metal inert gas arcwelding) automatic heads may be mounted on the manipulator. The electrical console provides all the necessary controls for complete programming of the welding operation. *Air Reduction Sales Company, a Division of Air Reduction Company, Inc.*

Circle number (16) on reply card.

Nonionic Surface Agents. A new "J" series has been added to the Poly-Tergent line of nonionic surface active agents introduced earlier this year. An outstanding characteristic of the new series is the wide temperature range over which the products are effective. Extending from 0 to 100 C (-32 to 212 F), this range is greater than that available through most other large volume nonionics. One member of the series, Poly-Tergent J-500, can be used at the boiling point of water without serious loss of its surfactant properties. The "J" series consists of 4 products of ascending molecular weights. All are aliphatic polyoxyethylene ether alcohols. They are clear liquids of low viscosity, pale yellow to amber in color, and with a mild, pleasant odor. All members of the series are good wetters, detergents, and dispersants. They are stable under a wide range of conditions, and because of their effectiveness at low concentrations they can be employed under many conditions of marginal compatability. J-500 will break many types of crude petroleum oil emulsions and can be combined in various ratios with J-200 to give stable oil-in-water emulsion. *Olin Mathieson Chemical Corporation, Industrial Chemicals Division.*

Circle number (17) on reply card.

Surface Pyrometer. A new low cost Surface Pyrometer for the instantaneous taking of temperatures of all types of surfaces is being manufactured. It will check surfaces as small as ¼ in. and its order of accuracy is 2 percent over the entire scale. Portable and weighing only 1½ lb, the instrument is chrome plated throughout, providing an external reflective surface that prevents the absorption of heat that would normally change the cold junction temperature. A calibrating thermometer, which is built into the unit, is positioned in the immediate vicinity of the cold junction, thereby providing a more accurate means of cold junction calibration. The thermocouple is insulated with refractory heads. Tip can be held firmly against the surfaces to be checked. Thermocouple may be easily replaced. *Pacific Transducer Corp.*

Circle number (18) on reply card.

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Put Economy and Flexibility in your Pipelines

STANDARD and LIGHTWEIGHT
ALUMIRON COUPLINGS
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For Grooved End Pipe

● Think back—remember the effort required to make and complete pipeline joints? Now you can do it an easier way with these two-bolt malleable iron Couplings. Pipeline progress dictated the design of Alumiron Couplings making them the simple, quick, positive, low cost way to join grooved-end steel, aluminum, cast and wrought iron and spiral pipe.

● Alumiron speedily joins grooved-end pipe by the mere tightening of two bolts which run through the coupling halves. The Buna N or oil resistant Neoprene gasket inside the coupling halves firmly and evenly grips the pipe ends making a leak-proof seal which increases as pipeline pressure mounts. This flexible Coupling permits the line to "come and go" with rough and uneven terrain. Component parts are interchangeable with other grooved-end couplings.

● Standard Series to 1,000 PSI working pressure in sizes 1" through 8". Lightweight Series to 500 PSI working pressure in sizes 2", 2½", 3", 4".

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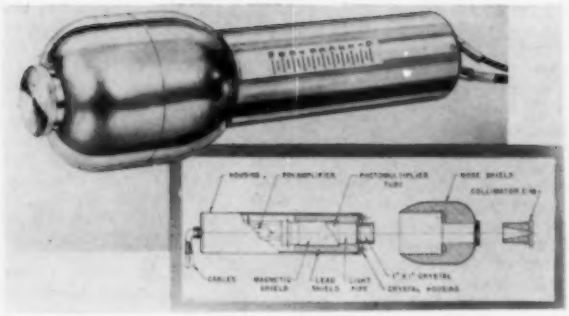


Radiation Instrument. Another new radiation instrument now available from Technical Associates is their Model SD-1 scintillation detector. This radiation detection instrument is designed for operation with scalers, ratemeters, or gamma ray spectrometer systems. When used with Model DS-5 Decade Sealer, the SD-1 is an important laboratory tool for medical and other scientific research purposes. The design of the SD-1 emphasizes its flexibility of use by the simple addition or removal of various accessories. *Technical Associates.*

Circle number (21) on reply card.

Salt Water Aluminum Bronze Pump. Designed to decrease the corrosive effects of oilfield salt water pumping, Fig. 3715 centrifugal chemical pump is now available in aluminum bronze. Fresh and salt water cavitation tests show that aluminum bronze excells chromium stainless steel 3 to 1; 18-8 steels 2 to 1; and standard manganese bronze 12 to 1 in resistance to salt water corrosion. While only 80 percent as heavy as regular bronze, it is exceptionally tough, having an impact strength of 20 to 30 Izod, and has a resistance to abrasion with a Brinell hardness, as cast, of 190. *Goulds Pumps, Inc.*

Circle number (22) on reply card.

Drip Trap Valve. The Enardo Model 529 drip trap valve features a positive leak proof shut-off. In the event of a high fluid level in the drip trap, it will not reopen until the excess fluid is drained from the trap. The body of the valve is made of non-corrosive Meehanite metal and the vinyl float is impervious to most corrosive fluids. Small lead weights are attached to the float arm to compensate for the buoyancy differential of fluids. Trap is designed for low pressure volume tanks on heater treater installations. *The Enardo Manufacturing Company.*

Circle number (23) on reply card.

Aid to Pipe Sticking. New tool which aids in solving the sticking of pipe opposite permeability because of differential pressure is called a Drill Pipe Differential Pressure Equalizer and Protector. Equipment reduces the area of contact of the drill pipe with the well bore, permitting the hydrostatic pressure to be equalized around the drill pipe. This tool employs steel rather than rubber for use in open hole. Before the 2 halves are welded together, flat springs (1/16-in. thick, 1-in. wide and 5-in. long) are placed side by side around the entire inside diameter of the equalizer. After the 2 halves are welded together these springs make a friction hold on the drill pipe. *Weatherford Oil Tool Company, Incorporated.*

Circle number (24) on reply card.

Scintillation Detector. Increased safety in airborne oil and uranium surveys was a key consideration in the design of the Cardinal, a new aerial-mobile scintillation counting system. Optimum efficiency is maintained at altitudes and speeds in excess of those to which conventional aerial counters are restricted. An automatic alarm circuit signals the pilot whenever an anomaly is passed and enables him to give his full attention to flying. Alarm indication is made by a series of lights flashing on the meter box or by horn if an audible signal is preferred. The Cardinal weighs 17 lb complete and can be used in aircraft. *The Radiac Company, Inc.*

Circle number (28) on reply card.

Air-Cooled 56 HP Engine. Wisconsin Motor Corporation's new Model VR4D offers a greatly expanded power range in heavy-duty, industrial type air-cooled engines. This engine is rated at 56 hp at 2200 rpm. Features include Stellite exhaust valves and valve seat inserts, used in conjunction with positive-type valve rotators for longer valve life, and tapered, self-cleaning, main roller bearings on both ends of the crankshaft. *Wisconsin Motor Corporation.*

Circle number (25) on reply card.

Paraffin Scraper for Pumping Oil Wells. Using a continuous-spiral design, new model features a single spiral wing, running the full length of the sucker-rod. It cuts running time by eliminating intermittently-spaced wings which can bunch and hang on well tubing. Longer spiral circles the rod only once each 15 in. and offers less drag.

In the center of the sucker rod, direction of the spiral is reversed. This resists torque and eliminates the possibility of rod joints unscrewing. Wing is fastened in place with steel clips pressed around the rod under high pressure. *Sunshine Iron Works.*

Circle number (26) on reply card.

Silicone Rubber. A very tough, strong heat-stable silicone rubber has been developed. Identified as Silastic 916, the new stock combines all the thermal stability and high dielectric properties characteristic of silicone rubber with a mechanical strength and abrasion resistance closely approaching that of conventional organic rubbers. Silastic 916 is also non-toxic, serviceable at extreme low temperatures, and is easily processed. It does not "nerve up," but can be milled and compounded after shelf-aging almost indefinitely. Suitable for molding, extruding or calendering, it can be hot-air vulcanized. It also remains firmer in the unvulcanized state, thereby minimizing possible distortion of extruded shapes prior to curing. *Dow Corning Corporation.*

Circle number (27) on reply card.

Tank Gage. On the market is a new automatic tank gage for measuring product under pressures of 150 to 300 lb. Gage is said to bring new accuracy and safety to gaging tanks in which hand gaging is impossible and gage glasses are often inaccurate.

A Neg'ator Motor, which is a constant torque spring, exerts a restraining force which does not increase as this elastic member is extended, thus giving consistent tape readings regardless of the position of the float. In addition to providing accuracy, design also eliminates the conventional counterweight, with its supporting tape and housing. *Shand & Jurs Company.*

Circle number (29) on reply card.

Carbide Insert Saw Tooth Bit. New tungsten carbide insert saw tooth core bit utilizes advanced technique in engineering and design. Core bit works like a saw but operates on the conventional rig to bring-up extremely smooth cores. Extensive field tests have shown bit to be best for coring coarse grained sandstone, shale slate, limestone, etc. *Hoffman Bros. Drilling Company.*

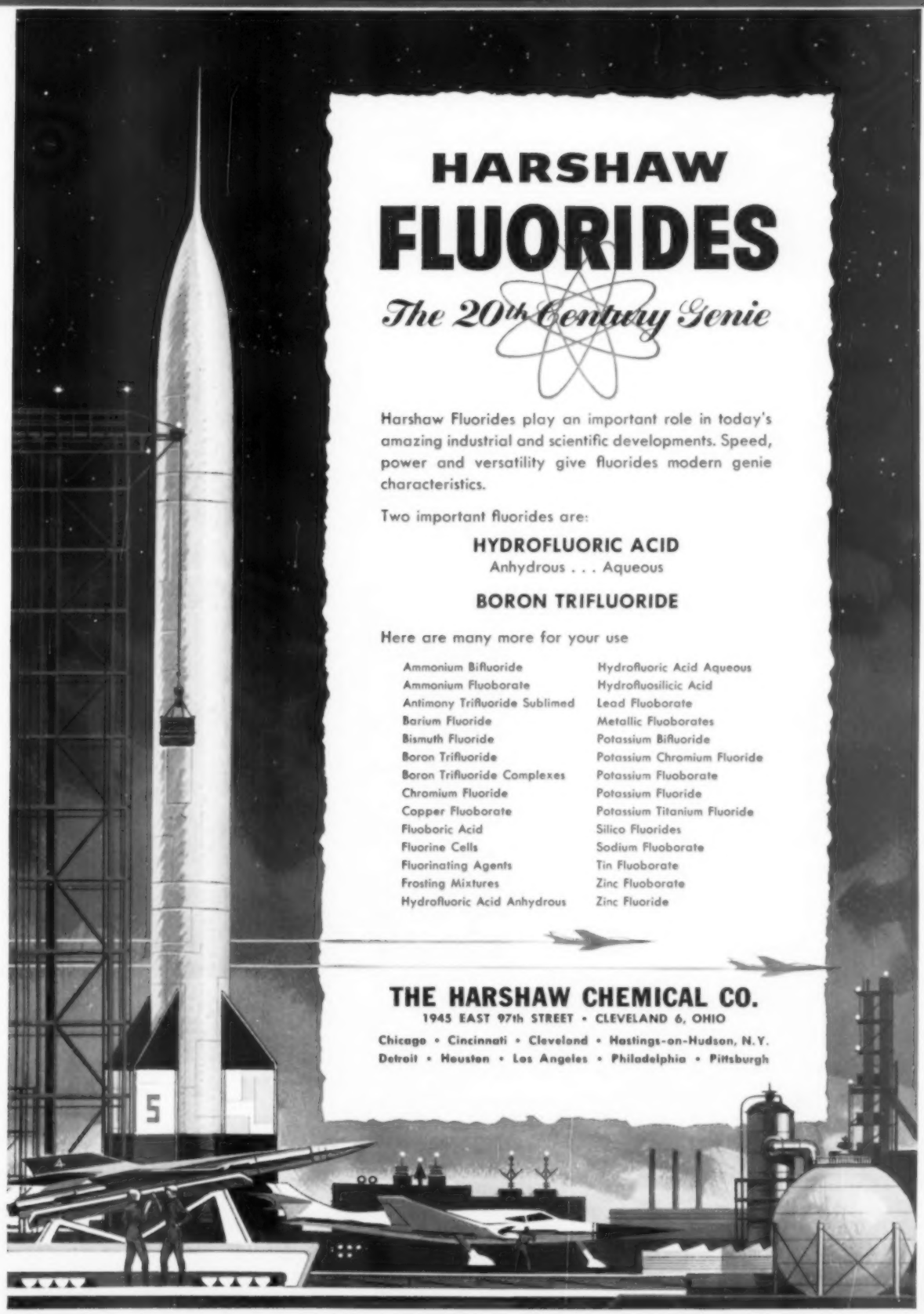
Circle number (30) on reply card.

Portable Measurement Instrument. An improved portable measurement instrument, called the Atlas Probetector, which determines accumulations of explosive gases, is now being produced. The unit, Model 504, has been designed for use where there is a possibility for accumulation of explosive gases. Concentrations of gas, below the lower explosive limit of the gaseous atmosphere in which the instrument's probe is placed, are registered on a direct reading explosive meter. Factory calibrated for methane and ethane gases, it may be obtained with calibrations for other gases. *Atlas Laboratories, Incorporated.*

Circle number (31) on reply card.

New Separator. A new short shell length separator for maximum conservation of oil and gas is being produced. Known as COG, it is a vertical low pressure separator with the shortest practical shell length. Designed to operate at the lowest possible pressure, it has sufficient pressure at all times to push oil through the lines into tanks. *National Tank Company.*

Circle number (32) on reply card.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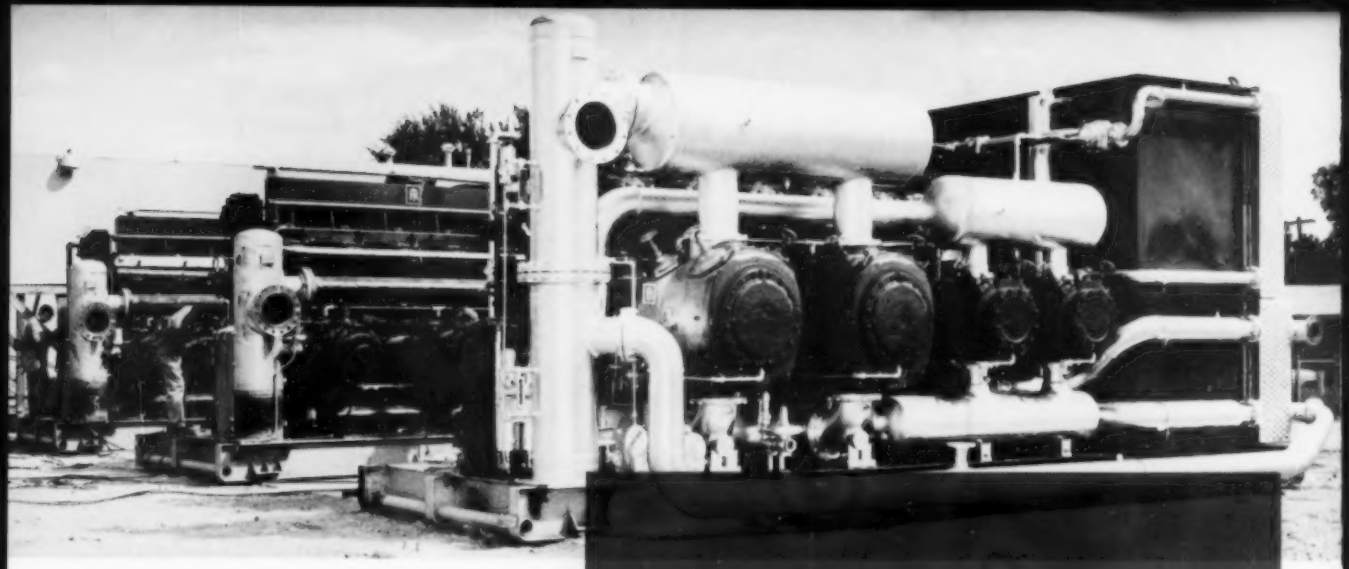

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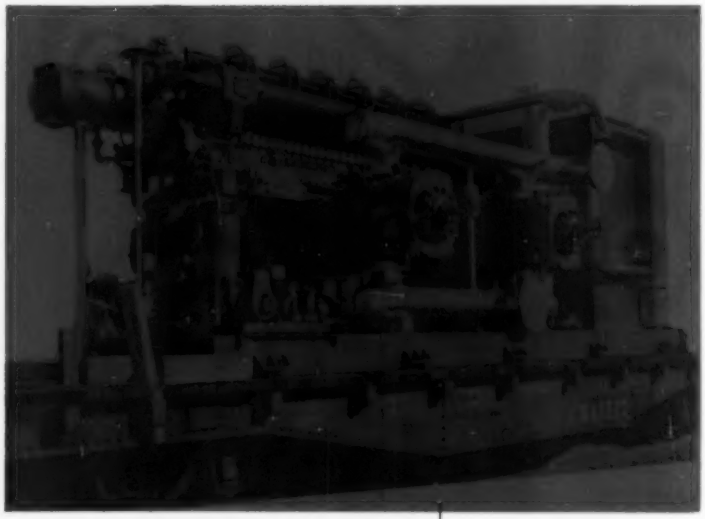

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New Projects in refining gas processing petrochemicals

A vacuum pipe still of 80,000 bbl per day capacity is under construction for The Texas Company at Port Arthur, Texas, refinery. It will be completed early in 1958, will include a 165 ft fractionator, five vertical heaters. Fluor Corporation, Ltd., has handled both the mechanical engineering and the construction. When this unit is completed old units totaling 60,000 bbl per day capacity will be withdrawn, giving a net increase of 20,000 bbl per day crude capacity for the refinery.

Three ethylene oxide units are being built, two in the United States and one in England. Capacity of each will be 60 million lb of the oxide per year. One for Wyandotte Chemicals Corporation plant at Geismar, Louisiana, near Baton Rouge, the oxide so made will be converted largely to glycol. Calcasieu Chemical Corporation's unit at Lake Charles, Louisiana, will also make glycol. At Partington, England, the Shell affiliate Petroleum Chemicals Ltd. will have the third plant. All are being built by the Lummus Company and will employ the new Shell process where ethylene and oxygen are reacted over a silver catalyst in a fixed-bed reactor.

Sixty tons of sulfur per day will be recovered from waste gases from Esso's Bayway refinery near Linden, New Jersey, in a unit being built by Girdler Corporation for General Chemical Division of Allied Chemical and Dye Corporation. The unit will remove hydrogen sulfide and oxidize the sulfur to the molecular state; plant will be completed late this year.

A new gas purifying plant has been authorized for Dow Chemical Company, at Bay City, Michigan, to be engineered and designed by Girdler Corporation, built by the Austin Company. Unit will use gases from Bay Refining Corporation refinery nearby. Capacity and date of completion of the unit have not been disclosed.

The Texas Company will build a large nuclear radiation laboratory at the Beacon, New York, research and development laboratories, to be completed in April 1958. There will be three radiation sources: A 6-million volt linear accelerator; a 3-million volt Van de Graff generator; and a 35,000 curie cobalt 60 source of gamma radiation.

More sulfur from Calgary. 300 tons-per-day of sulfur from gas from the Okotoks field, near Calgary, Alberta, will be built by Shell Oil Company. Plant will be completed in 1958 and will treat 15 million cu ft of desulfurized gas daily, to be sold locally. Devon Palmer Oils Ltd. is expected to operate the plant.

Whole new refinery at Colon, Panama, will be built by Panama Refining and Petrochemical Company, for 55,000 bbl per day crude capacity. Plant will cost $33 million and is to be completed within two years. It is to be built by Foster Wheeler Corporation, construction is slated for mid-summer or early fall. Crude will be obtained from U. S. oil companies under new contracts, and plant output is contracted for "over a period of 10 years." Plant is owned by Eugene duPont III, Wilmington, Delaware, and John Shaheen of New York.

A Boron Chemicals plant will be built at Lawrence, Kansas, by Callery Chemical Company, owned jointly by Gulf Oil Corporation and Mine Safety Appliances Company. This is a boron specialty chemicals unit, products to be sold for commercial purposes. Callery is building a high energy fuels plant at Muskogee, Oklahoma, for the Department of the Navy. This second plant will cost "between $3 and $4 million"; the building contractor has not been named.

A new and larger crude unit at Grangemouth will raise the crude capacity of the British Petroleum Company refinery by 18,000 bbl per day. An old unit will be replaced by the new one. New capacity will cost $12 million, including a larger jetty at Finnart near Loch Long, Scotland, to handle the largest tankers. The new capacity will take all the crude the pipeline from Finnart to the refinery will carry. The crude still will be completed in 1959, the jetty in late 1958.

Panama Refining, Inc., has completed an agreement for a large refinery in Panama, with that government, but has not closed construction or engineering contracts. This company is a subsidiary of D. K. Ludwig's National Bulk Carriers.

Champlin Oil and Refining Company will have Badger Manufacturing Company build a 1430 BPD hydrofluoric acid alkylation plant at Enid, Oklahoma. It will cost about $1.9 million and will use the Phillips process. Initial operation is scheduled for March 1958.

Richfield Oil Corporation is going to build a refinery on Puget Sound near Everett, Washington, in about 1965. A 50,000 BPD plant is planned; it will be built when Richfield's sales in the area reach 35,000 BPD. Current level is about 25,000 BPD, increasing about five percent per year.

Standard Oil Company of California will construct a $3-million paraxylene plant at its Richmond refinery to increase its output of this chemical 25 million lb a year. To be adjacent to the present paraxylene plant, the new unit will be ready in early 1958.

Gulf Oil Corporation will build a UOP "Penex" isomerization unit "sometime by 1960." The hydroisomerization process will increase octane number of leaded pentane from 88 to 106, Research; hexane, from 65 to 95, leaded. No announcement on where the plant would be located.

Atlas Processing Company will install the first Penex hydroisomerization unit at its Shreveport, Louisiana, gas liquids processing plant. It will cost about $3 million, be built by Hudson Engineering Corporation. Completion is planned for March 1958.

Two new refineries for Florida? Plans for a refinery at Jacksonville will be announced soon, we are told. Another plant is under consideration, but no conclusions have been reached as yet.

Synthetic glycerine production will receive a boost by the construction of a second unit at Dow Chemical Company's Freeport, Texas, plant that will double Dow's capacity there. Process is Dow-developed, starts with chlorine and propylene. Plant will be completed about March 1, 1958.

Humble Oil & Refining Company will build a 750-million cu ft per day gas processing and cycling plant . . . the world's largest . . . in the Corpus Christi area next year. To cost about $75-million, the plant will recover about 25,000 BPD of gas liquids.

Ben Franklin Refining Company will build a UOP hydrofluoric acid alkylation unit at its Ardmore, Oklahoma, refinery. The 1000 BPD plant will be constructed by The Refinery Engineering Company.

Standard Vacuum Oil Company will expand its Bombay, India, refinery 5000 BPD, up to 33,000 BPD, at a cost of $10.6 million. New units will manufacture asphalt, LPG, solvents, jute batching oil, and turbo-jet fuel.

Ethyl research takes a new approach to match future fuels and engines

By H. J. GIBSON, Technical Director, Ethyl Corporation Research Laboratories

COMBUSTION characteristics of future gasolines in tomorrow's engines have been defined in an extensive study recently completed in the Detroit Research Laboratories of Ethyl Corporation. This project pursued these two basic objectives.

First, to find out how variations in hydrocarbon composition, sensitivity and other characteristics would affect the ability of gasolines to meet the fuel requirements of tomorrow's engines.

Second, to determine how future engines could be modified to permit effective use of the widest possible range of fuel characteristics.

Engine Adjustments Lower Octane Requirement

Three high-compression test engines were selected for their high volumetric efficiencies and because each represented a different philosophy of combustion-chamber design. Compression ratios were increased to 11-to-1, a ratio that can be expected in passenger car engines in the near future.

Each engine was completely calibrated on an engine dynamometer in order to assure realistic tailoring of the carburetion and ignition characteristics of the engine for the most effective use of commercial-type gasolines.

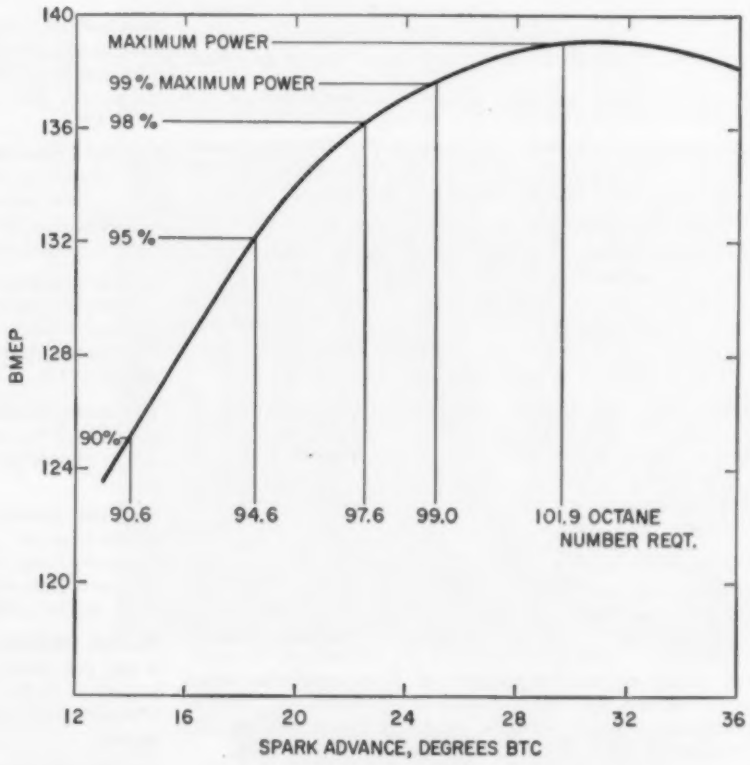
The engines were then installed in automobiles for road ratings of the fuels under test. Over one hundred commercial-type gasolines, including a wide variety of hydrocarbon compositions, were rated in these vehicles under carefully controlled conditions on a chassis dynamometer.

Results of the investigation indicate that a number of compromises can be made between engine performance and engine-fuel requirements.

For example, it was possible to lower the octane requirement with only nominal power loss and without significantly affecting fuel economy, by adopting slight modifications of spark advance and carburetor design.

It was further shown that it will be desirable for refiners to maximize the paraffinic and aromatic contents of their fuels in order to attain satisfactory operation at high engine speeds.

Low-cost olefinic blending components will continue to be effective in meeting the Research-octane-number specification required to satisfy the engine at low speeds.



This graph illustrates the relation between ignition timing and engine output for one engine at one speed. With ignition timing set for maximum power, the antiknock requirement is 101.9 octane number. When ignition timing is retarded to 99 per cent of maximum power, the octane requirement is reduced to 99. Thus, engine requirement can be reduced 2.9 octane numbers by sacrificing only one per cent in power.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Equation Predicts Road Octane Number

Using a digital computer, Ethyl statisticians analyzed the vast amount of data obtained from the tests. Extensive correlation equations were developed to aid refiners in blending their gasolines to the actual road antiknock requirements of current and future cars.

The best linear relation existing between road octane number and fuel-inspection data, such as Research and Motor octane numbers and hydrocarbon composition, was determined for each car.

Analysis of these equations showed Research and Motor octane numbers do a good job of defining road gasoline performance at low engine speeds.

At high speeds, however, consideration of gasoline composition, in addition to Research and Motor octane numbers, is useful in predicting gasoline antiknock performance. The correlation equations took the following form:

ROAD OCTANE NUMBER = A
+B ***(Research Octane Number)***
+C ***(Motor Octane Number)***
+D ***(% Olefins)***

where A, B, C, and D are constants determined by analysis.

Additional properties, such as the volatility of the gasoline, do not materially enhance the degree of correlation.

Ethyl studies of the potential of future fuels and engines continue. The results will be distributed to oil companies. The data also will be discussed with automotive companies to acquaint them with the probable composition of future fuels as they may affect future engine design.

We believe such efforts will help to preserve a reasonable relationship between the advantages of high compression engines and their octane requirements.

In Ethyl's extensive road-rating program a digital computer was used to provide maximum statistical interpretation of the test data.

How Ethyl Research Is Helping You

Because of Ethyl's interest in the mutual problems of the petroleum refiner and automobile manufacturer, the extensive research program briefly described here was initiated to define the antiknock performance of future gasolines in tomorrow's engines.

This progress report is one more example of how Ethyl Research—outstanding in the study of engine-fuel relationships—continues to be of service to the petroleum industry.

Copies of the detailed report, "Matching Gasoline Antiknock Performance and Future Engines," presented at the May, 1957 meeting of the API Refining Division at Philadelphia, may be obtained from your Ethyl representative.

ETHYL CORPORATION
New York 17, N. Y.

RESEARCH LABORATORIES:
1600 W. Eight Mile Road, Ferndale 20, Mich.
2600 Cajon Road, San Bernardino, Calif.

Tidewater Oil Company's Delaware refinery sets new industry standards for individual unit capacities, instrumentation, layout, and minimum manpower requirements

Whit Downer
Associate Editor

ONSTREAM for just a few months and formally dedicated a little over a month ago, Tidewater Oil Company's Delaware refinery holds more "firsts" than any other refinery in the world. Its nominal crude oil capacity, 130,000 bbl per stream day, ranks it as being the world's biggest refinery ever built from the ground up. Its 11 major process units include six that are in the "world's largest" category. These are the major process units:

*Crude Distillation	130,000 bbl per stream day
*Fluid Coking	42,000 bbl per stream day
*Catalytic Cracking	102,000 bbl per stream day
Gas Recovery Plant	88,000 M cu ft per stream day
Polymerization	5,200 bbl per stream day (Prod.)
H_2SO_4 Alkylation	5,000 bbl per stream day (Prod.)
*Catalytic Reforming	45,200 bbl per stream day
*Reformate Extraction	40,300 bbl per stream day
*Hydrodesulfurization	88,000 bbl per stream day
Hydrogen Plant	30,000 M cu ft per stream day
Sulfur Plant	200-340 LT sulfur per day

*World's Largest.

In addition to mere size, each of the process units can be described as being the most modern of its type. Spacious layouts ease maintenance problems. A complex information system, including automatic data loggers at each unit, assure close control, accurate operating and accounting information, and minimum process operating manpower.

Replacing Tidewater's outmoded, now-abandoned refinery at Bayonne, New Jersey, the Delaware refinery places the company in the position of a leader in East Coast refining and marketing. There is not much doubt that the refinery can turn out products with the most superb quality characteristics, and its capacity is about 10 percent of the total on the East Coast.

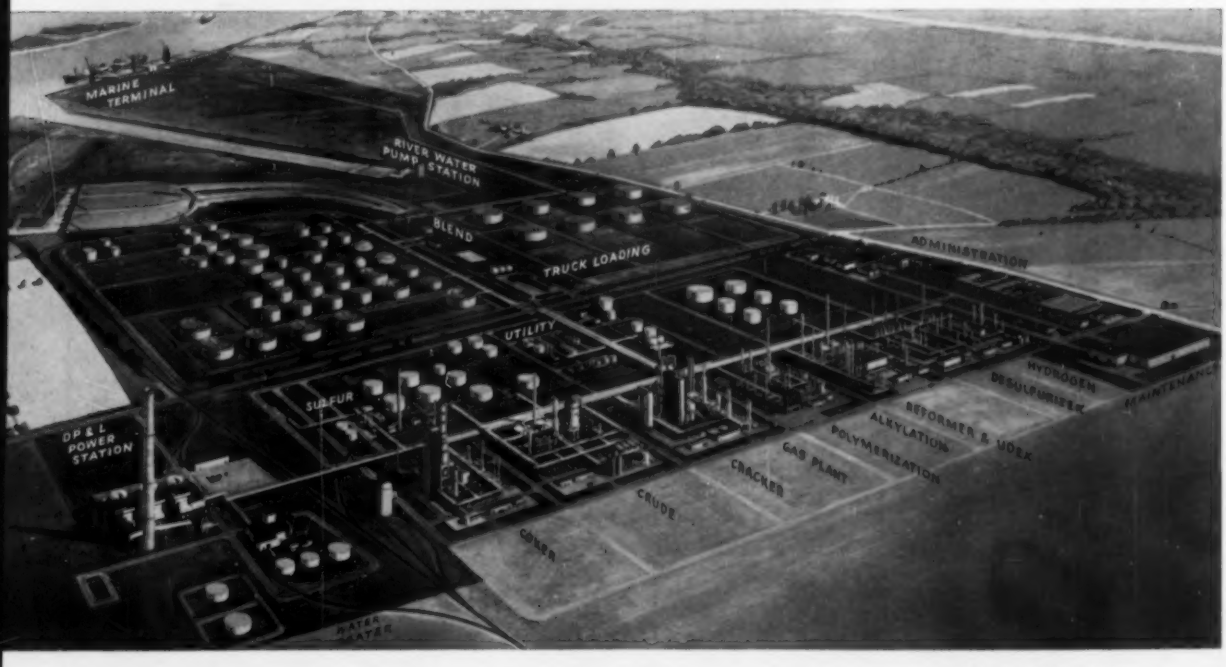
The Story Behind the Move to Delaware

It was in 1953 when Tidewater realized that the old refinery at Bayonne either had to be modernized or replaced if the company were to remain in a good competitive position. To this end, Tidewater retained C. F. Braun & Co. to survey the situation at Bayonne, and to aid in making a decision.

The decision was clearcut: Move. The detailed and exhaustive studies showed that modernization of the Bayonne plant was unfeasible for many reasons, some of which were:

1. The refinery was not equipped to process lower-quality, lower-priced crudes into high-quality products.
2. The plant had grown like Topsy, over a period of about 65 years and the many small, older process units were responsible for extremely high processing and maintenance costs.
3. Lube oil operations at Bayonne had become a lower-volume, lower-profit operation.
4. Utility systems and other auxiliaries were antiquated and inadequate.
5. Waterfront facilities couldn't handle today's giant tankers.
6. The site was not well-suited for construction of new facilities, and there was no room for further expansion.
7. Local taxes were getting out-of-hand.

After considering these factors, Tidewater and Braun agreed that there was but one reason for staying in Bayonne: Inertia. Obviously, this was not a very compelling reason for staying.



— Courtesy C. F. Braun & Co.

World's Largest Grass-Roots REFINERY

The huge catalytic cracker and its attendant facilities make a fascinating night-time scene. The Orthoflow unit is the largest fluid cracker ever built: It's designed to process 102,000 BPD of gas oil, including 75 percent recycle on fresh feed.

Birth of a Giant

A decision was made . . . Tidewater would build a new East Coast refinery at a location other than Bayonne.

Another hurdle to cross was that of location. Detailed studies by Tidewater showed that a 5000-acre site on the Delaware River, just a few miles out of Wilmington, would be ideal. It was centrally located from the marketing point of view, was accessible for the largest tankers, there was a plentiful source of labor at reasonable rates, and soil conditions were excellent.

Tidewater then laid down the basis premise upon which the new refinery would be constructed:

It would be the world's most modern, designed to produce the highest quality products from low-grade crudes with a maximum of efficiency, flexibility, and economy.

C. F. Braun & Co. was given the responsibility of fulfilling this premise, receiving the contract for overall engineering, design and the construction of the refinery under Tidewater's direction.

Growth of an Engineer's Dream

The rest of the story is refining history. Out of the rolling hills of Delaware, near the quaint little town of Delaware City, there grew a refining colossus. Completed at a cost of about $200-million, there were more than 10,000 workers on the site during many periods. And, despite the enormity of the project, completion was within two years of initial construction work.

Some may speculate that the superlatives surrounding this refinery are an end rather than a means. Such could not be further from the truth. Every phase in the decision to build the refinery, site selection, process selection and design, choice of instrumentation and other auxiliaries was based on hard and fast economics and engineering logic. It was on sound principles that this one-line refinery, with only one unit of a kind, equipped with the most modern equipment and materials available, grew.

Refinery Layout

As shown in the artist's concept of the refinery, the operating units are arranged in a straight line, beginning with the power and steam plant at the northern extremity, ending with the hydrosulfurization facilities at the southern end of the plant. The sulfur plant, not in the primary process line, is across a roadway from the fluid coker.

It's a long walk from one end of the refinery to the other . . . about 4500 ft, not including the power plant. If counting it, too, the units stretch over former farm land for almost a mile!

To the east of the refinery, between the process units and the flat-lands adjacent to the river are the crude, intermediate prdouct, and product storage tanks. Storage capacity is about 7-million bbl. The gasoline and fuel oil blending facilities are, of course, in the heart of the tank farm.

Spaciousness keynotes the individual process unit layout. Wide alleys separate rows of pumps and heat exchangers. Rail-mounted frames for pulling exchanger bundles facilitate maintenance. Vessels are set far enough apart to minimize working in cramped quarters during turnarounds. The control houses are set well away from the process units and have a large picture window from which the entire unit can be seen.

In fact, the very size of each unit is such that the process operators sometimes use bicycles to get around in a hurry!

In addition to housing control panels and the data logging facilities, offices are incorporated into the control houses. The convenient and attractive offices are for the unit foremen, staff engineers, area maintenance supervisors, and others responsible for day-to-day operations.

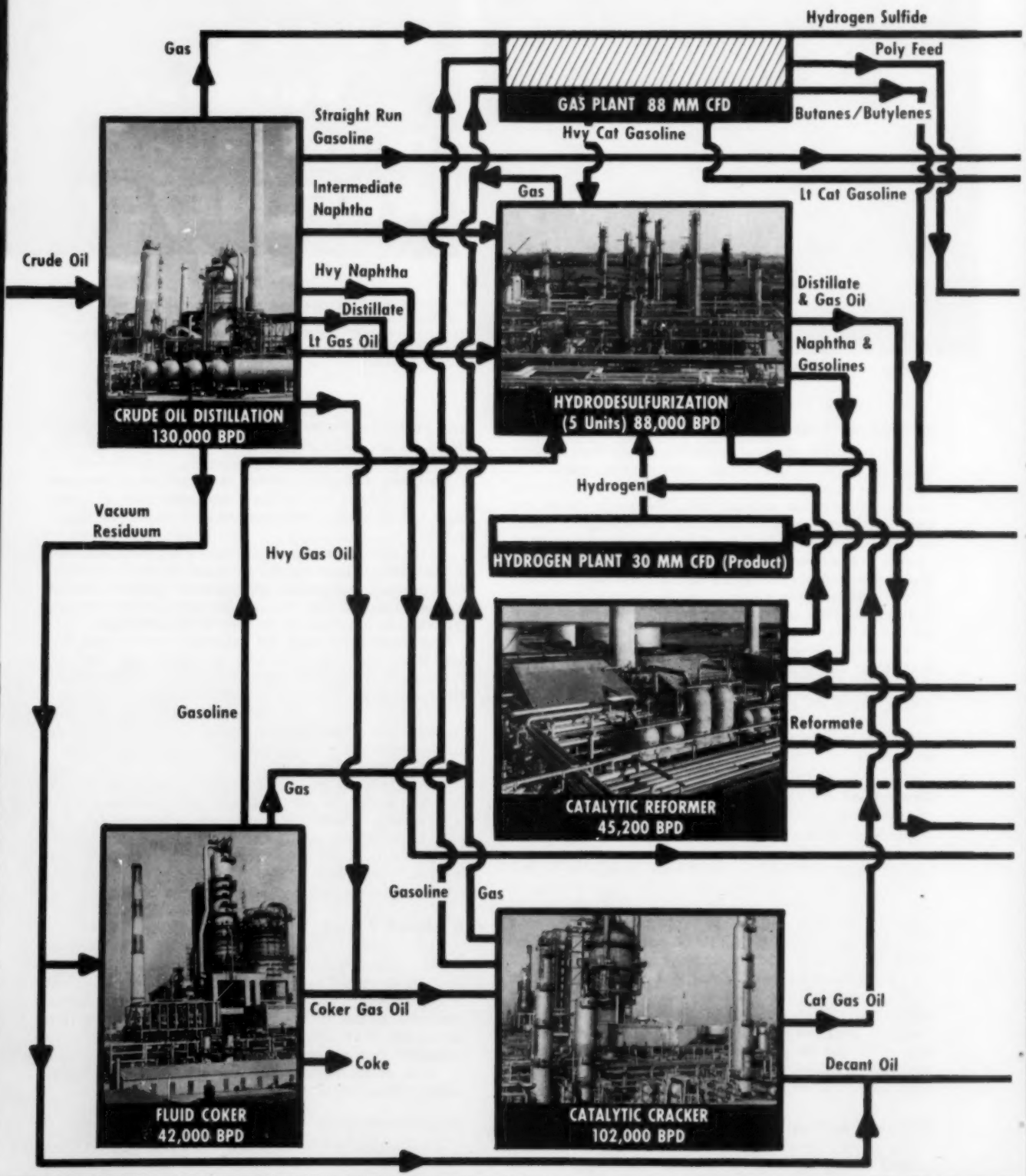
A Glance Ahead

The process and engineering story of the Delaware refinery is told on the following pages. First, process operations are described, accompanied by flow diagrams of each of the mammoth process units. This is followed by a brief discussion of the utilities systems that support the process operations. Even after digesting some of the superlatives contained in those sections, you will continue to be amazed by some of the construction highlights and metallurgical aspects that conclude this special section.

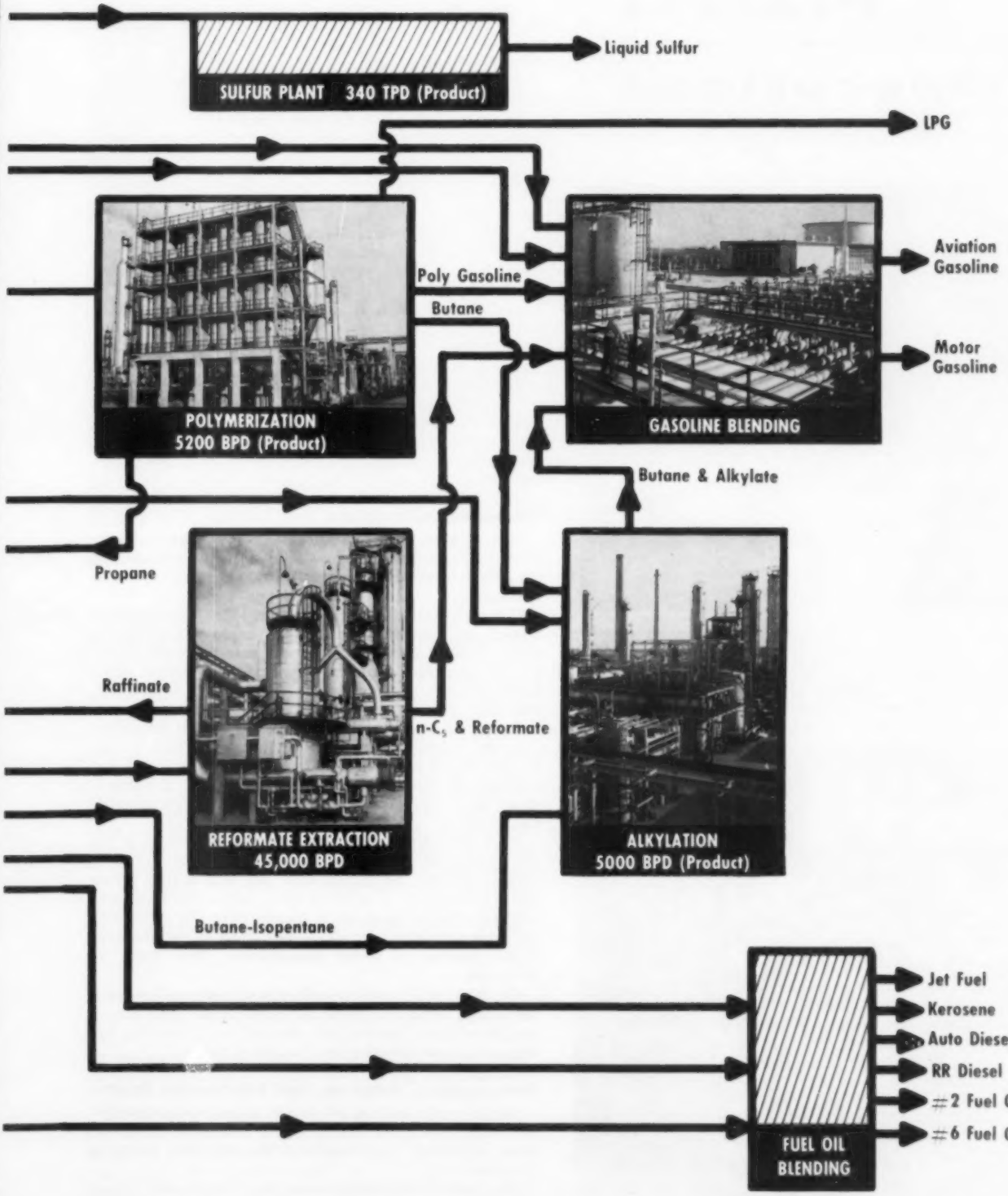
Acknowledgment

We are indebted to Tidewater Oil Company and C. F. Braun & Co. for the pictures, flow diagrams, and background material that made this presentation possible.

PICTURED FLOW DIAGRAM OF

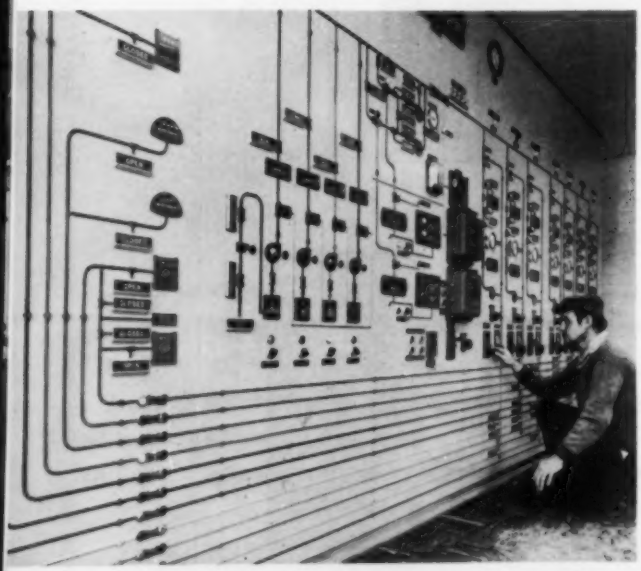


THE DELAWARE REFINERY



Process Operations

Control console and part of the graphic panel in the catalytic cracker and gas recovery plant control room. The plugs immediately in front of the operator can be put into proper sockets for either a digital reading or trend recording. Under the glass top on the desk is a detailed flow diagram. Mounted on a scroll at either end, the operator can shift the chart to study all parts.



The control panel in the tank farm control house includes push-button controls for the pumps, valves, and proportioning devices that regulate the flow of refinery raw material and products.

The Delaware refinery is designed for operating flexibility. Intermediate tankage makes possible operation of most other refinery units in the event that one is down on either an emergency or scheduled maintenance basis. Heat exchanger trains, reactors, etc., are provided in sufficient number to maintain optimum operations. For example, the 45,000 BPD catalytic reformer has two reactor (and preheat and inter-heater) trains to permit the most efficient type of operation.

Similarly, the sulfur plant has two reactor trains to handle the widely variant sulfur production. Sulfur production is dependent, of course, on the type of crude in process, ranging from quite sweet to the most sour imaginable. The hydrogen plant, provided to supplement hydrogen supply to the hydrodesulfurization unit from the cat reformer, likewise has two converter furnaces and reactors to allow for varying demand.

Almost any type of crude in the world can be processed by the crude distillation unit. The desalter will handle the highest-salt content crudes produced. Proper selection of metals . . . and very high hydrodesulfurization capacity . . . enable the refinery to process the highest sulfur content crudes.

In contrast to older refineries, there is no treating area *per se* at this refinery, except for the five desulfurization units that are incorporated into one process plot. Wherever possible, chemical treating units are located at the primary process units. Solutizers finish straight-run and heavy naphtha at the crude unit. C_3's, C_4's, light catalytic gasoline, and heavy catalytic gasoline are caustic washed at the gas recovery and catalytic naphtha fractionation plant.

Process Instrumentation and Control

Nine control rooms serve the entire Delaware operation. Seven are provided for the 11 process units, one for the utilities unit, and one for storage and product blending operations.

Common control rooms are shared by: The catalytic cracker and gas plant; the polymerization and alkylation units; catalytic reforming and reformate extraction units; and the hydrogen plant and hydrodesulfurization units. Individual control rooms serve the crude unit, fluid coker, and sulfur plant.

Pneumatic control and transmission is used in most cases since the average transmission distance is less than 250 ft. In most instances the lag in carrying out an "order" is not sufficient to cause undue operating difficulties. The reason stated for a pneumatic control system is straightforward: Less costly.

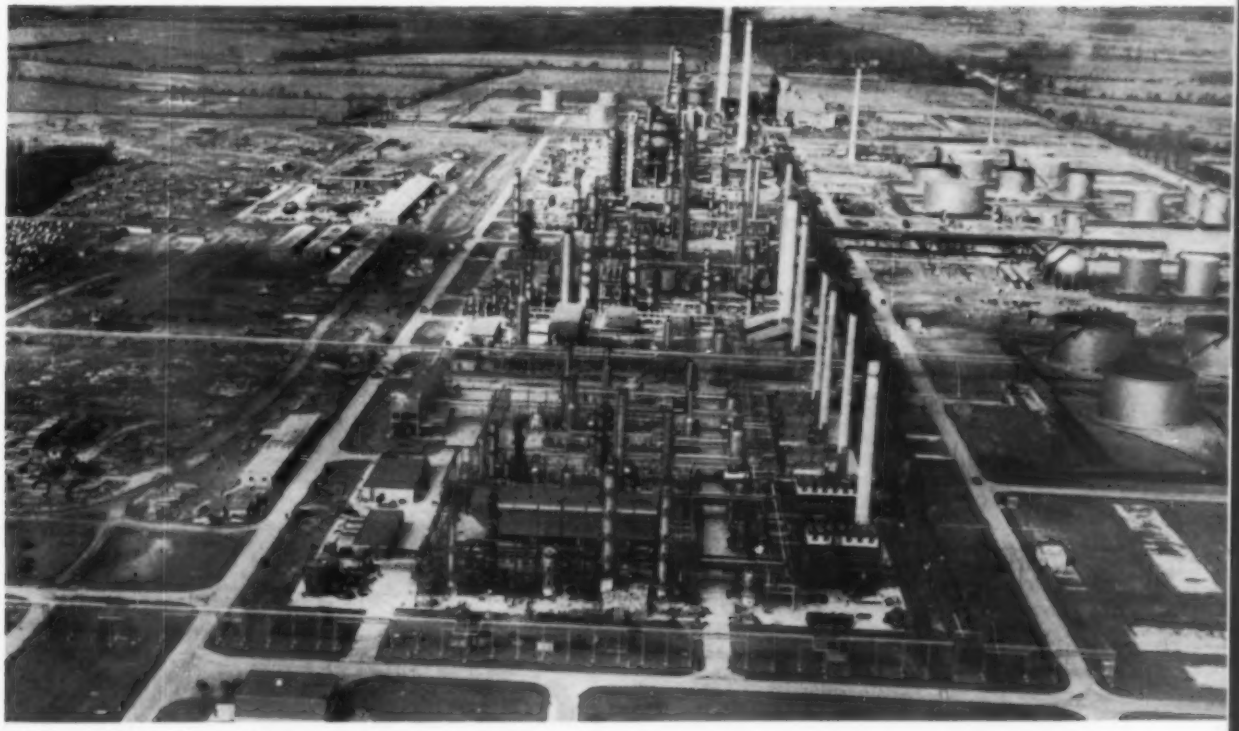
Each control room contains a graphic panel such as the one illustrated. Miniature recorder-controllers are used almost entirely. The "board man" sits at a console facing the graphic panel. A series of plugs, not unlike those in a telephone switchboard, are at his fingertips. By connecting the plugs with the proper socket, he can get an instantaneous digital reading of either temperatures, flow rates, or pressures.

Or, if desired, he can plug any temperature or flow point into one of the standard-size cabinet-mounted trend recorders behind him. This cabinet also includes trend recorders for fixed points that may be of a critical nature.

Data Logging, Scanning, and Information System

To the right and/or left of the console are automatic data loggers that print out hourly, or more often if desired, flows, pressures, temperatures, levels, and other operating variables.

There are 13 logging systems in the refinery, one for each operating unit plus a logger-computer for the storage and blending operation. A total of 4700 points can be recorded — the largest unit prints out 600 points, the smallest, 125.



The Delaware Refinery from the South. The hydrogen plant is in the right foreground, beside the desulfurization units. The next process block is occupied by the catalytic reformer and reformate extraction units. The power plant stack dominates the background.

Each of these units punch out a daily operating summary on tape, providing in coded form the same information that is on the accounting section of the log sheet. These tapes are sent to a central data processing facility where machines decode the information and print out a refinery-wide operating report.

A big feature of the data loggers is the scanning system that alerts operators to undesirable operating conditions. During the time that the logger is not printing out the normal data routine, it continually "sweeps" all of the data points. If there are any conditions that are outside of preset limits, that point is printed out in red type and an alarm light notifies the operator. There is a grouping of alarm lights on the operator's console; each is mounted below a red glass plate on which is printed the condition causing the alarm.

The scanning system continues to notify the operator until the situation has been corrected or an over-ride button is punched.

Tank Farm Instrumentation

Accurately-calibrated meters coupled with the continuous products blending facilities, record flows for control and accounting purposes. And, as pictured, a graphic panel incorporating pump stop/start switches and valve positioning knobs permits remote operation, for the most part.

All of the 88 tanks are equipped with electronic level gages and resistance thermometers. A special electronic computer coupled with the data logger integrates these data with the pre-set tank strapping and fluid characteristics, logging a complete inventory every eight hours. Other logged data includes tank number, level, tank fluid, fluid gravity group, temperature, and time.

These data are also coded on punched tape that is sent to the refinery's central data processing center for preparation of operating reports.

Laboratory Reports

Tel-autograph instruments connect each control room with the control laboratory. The sender merely "writes" his message with a stylus upon a metal plate and the writing is mechanically reproduced at the receiving station. The tel-autograph units provide a permanent written record of the laboratory tests, also relieve the operator from having to take down the data by telephone in the event that he is otherwise occupied.

Is the Complex Information System Justified?

In addition to the intangible . . . and sometimes very tangible . . . benefits accruing from greater accuracy and frequency of recording operating and accounting data, there were several economic considerations that made the complex information system desirable.

First, the control boards were simplified since many recording instruments were eliminated from the panel. The boards would have been 25 percent longer without the data loggers. Second, operating manpower requirements were either reduced or a man's duties made more productive than those of simply writing down data. Third, the punched tape used in conjunction with the central decoding and print-out machine reduced clerical manpower requirements. The control panels and information systems were designed and built by Panellit, Inc.

Process Units at the Delaware Refinery

Flow diagrams and some of the highlights of each process unit follow. Unless otherwise noted, Braun did the process design and engineering work in addition to procurement and construction.

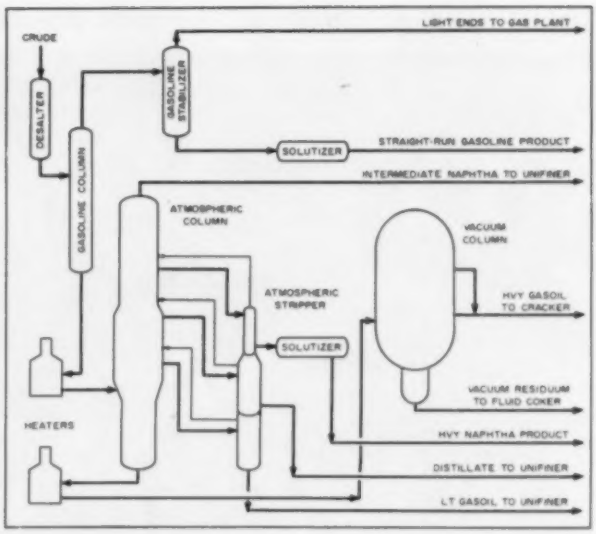
■ The 130,000 BPD Braun crude unit . . . the world's largest . . . is designed to process a variety of crudes regardless of sulfur content or presence of naphthenic acids. There are three towers: A prefractionator; a 23-ft-diameter atmospheric column, and a 40-ft

CRUDE DISTILLATION

vacuum tower — the biggest of its kind.

The heaters, now fired with standard plant fuel, are designed for the future addition of fluid coke burners. They are the first furnaces in the refining industry designed for fluid coke service.

Auxiliaries include a Petreco two-stage electrical desalter . . . the largest of its kind . . . disposal facilities for all of the refinery's foul condensate and the desalter water effluent, and solutizers for straight run and heavy naphtha. The solutizers use rotating disk contractors, smaller than the usual mixer-settler drums.

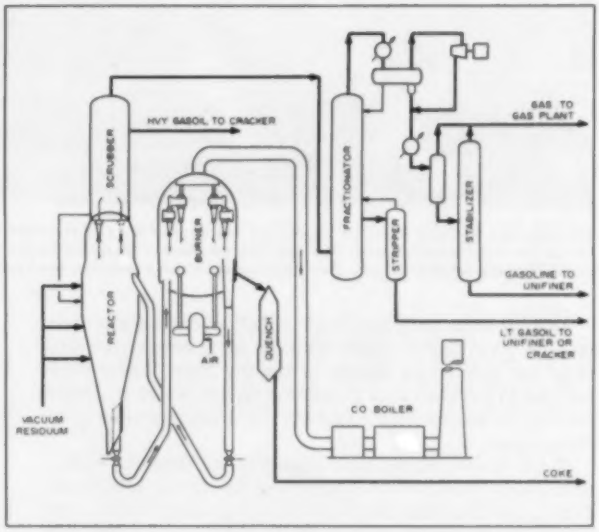


■ Selected to minimize heavy fuel oil production, the 42,000 BPD fluid coker is matched in size only by a twin at Tidewater's California refinery. It converts vacuum residuum into small particles of coke, heavy and light gas oil, naphtha, and gases.

FLUID COKING

Most of the 1600 T/D net coke production will be burned at the nearby power station. Stack gases from the coker's burner will fire a CO boiler that serves the double purpose of supplementing refinery steam supply and minimizing possible air pollution.

The fluid coking process is licensed by Esso Research and Engineering Company.

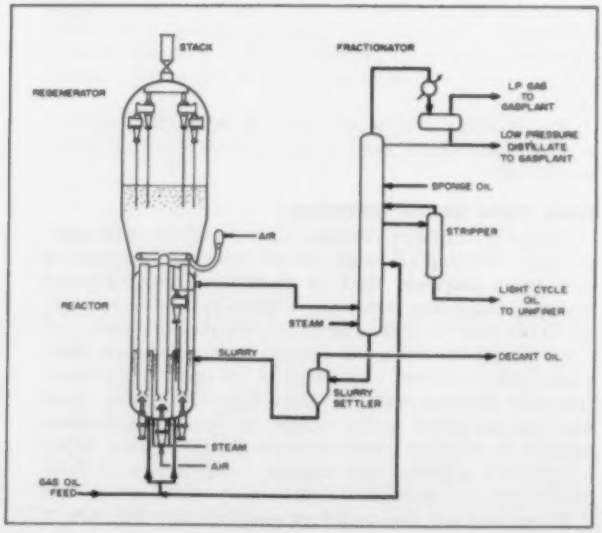


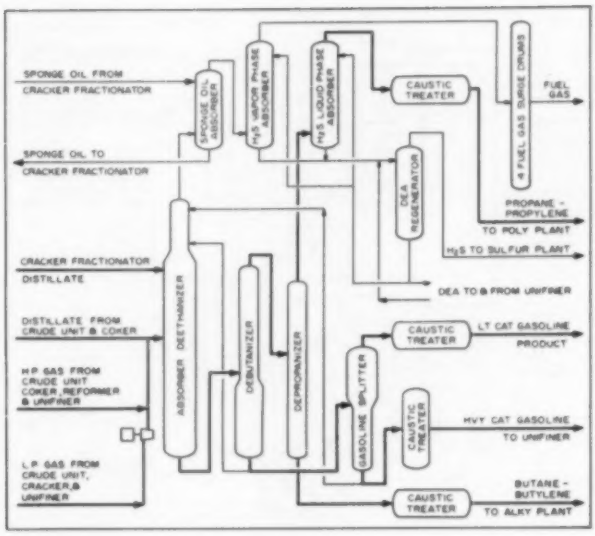
■ Another "world's largest," the Kellogg-licensed and designed fluid cat cracker will process 102,000 BPD of gas oil. Fresh feed from the crude vacuum tower and the coker totals 58,000 BPD; recycle is 75 percent on total feed. Product yields include 29,100 BPD of gasoline and 18,700 BPD of heating oil.

FLUID CATALYTIC CRACKING

Nearly as high as the fluid coker, the stacked reactor and regenerator soar 250 ft into the air. The regenerator is 59 ft in diameter, the reactor somewhat smaller. Also indicative of the unit's size is the direct drive condensing turbine that powers the main air blower: 11,250 hp!

Coke burning capacity is 58,000 lb per hr and the combustion air blower will deliver up to 161,500 cu ft per min to the regenerator.




SPONGE OIL FROM CRACKER FRACTIONATOR
SPONGE OIL TO CRACKER FRACTIONATOR
SPONGE OIL ABSORBER
H2S VAPOR PHASE ABSORBER
H2S LIQUID PHASE ABSORBER
CAUSTIC TREATER
FUEL GAS SURGE DRUMS
FUEL GAS
DEA REGENERATOR
PROPANE - PROPYLENE TO POLY PLANT
H2S TO SULFUR PLANT
DEA TO & FROM UNIFINER
CRACKER FRACTIONATOR DISTILLATE
DISTILLATE FROM CRUDE UNIT & COKER
H.P. GAS FROM CRUDE UNIT COKER, REFORMER & UNIFINER
L.P. GAS FROM CRUDE UNIT, CRACKER & UNIFINER
ABSORBER DEETHANIZER
DEBUTANIZER
DEPROPANIZER
GASOLINE SPLITTER
CAUSTIC TREATER
LT CAT GASOLINE PRODUCT
HVY CAT GASOLINE TO UNIFINER
BUTANE - BUTYLENE TO ALKY PLANT

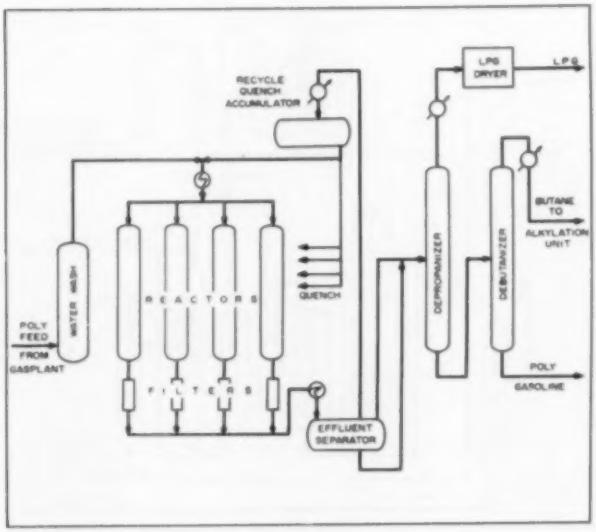
■ The gas recovery plant and cat naphtha fractionating system is another "biggest yet" assembly. It can process 88 million cu ft of gas daily. The three main sections of the plant incorporate absorption and fractionation, hydrogen sulfide removal, and treating units for the catalytic naphthas.

GAS RECOVERY PLANT

Built on the same plot as the cat cracker, the Braun-designed gas plant is in a central location for processing all refinery gases. It provides feed to the polymerization, alkylation, and sulfur plants, also separates light from heavy catalytic naphtha.

Much of the reboil heat for the plant's distillation columns is supplied by pump-around streams from the cracker products fractionator . . . this being another important factor in gas plant location.

Four gas storage tanks on the plot are designed to provide the refinery with 40 minutes' fuel gas supply in the event of a short-term shutdown.

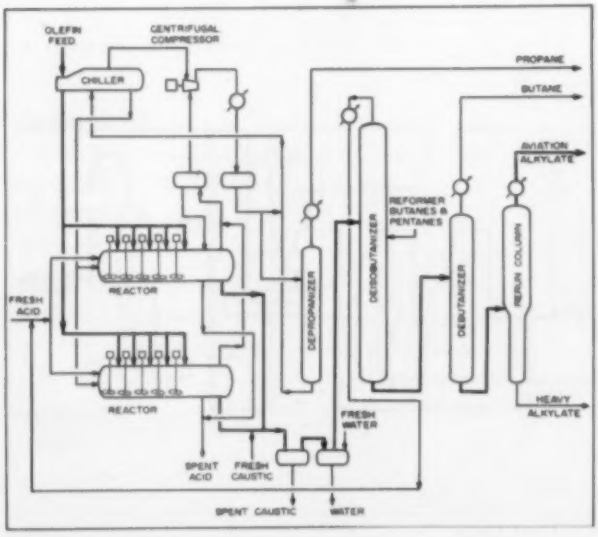


■ The U.O.P. poly plant is designed to produce, on a non-selective basis, 5200 BPD of polymer gasoline from refinery C_3 and C_4 unsaturates. It also provides 3900 BPD of

CATALYTIC POLYMERIZATION

butane and 4800 BPD of propane. Feed volume is 15,800 BPD. The unit can also operate on a selective basis to convert butenes to stock for avgas blending, following hydrogenation.

The chamber-type reactors are filled with Kieselguhr pellets impregnated with phosphoric acid. They normally operate at 350-450 F and 500-700 psig.



■ The alkylation unit processes 7500 BPD of refinery isobutane and butylenes along with 2900 BPD of purchased isobutane, making 5000 BPD of total alkylate. Aviation alkylate is about 95 percent of the "make."

SULFURIC ACID ALKYLATION

It is also designed to handle propylene and amylenes along with butylenes as limited by isobutane availability.

Heart of the unit is the two Kellogg Model C cascade reactors. Heat of reaction is removed from these units by auto-refrigeration, with regulation of propane inventory in the system holding the reactor temperature at 30 to 40 F. Since propane dilution adversely affects alkylate quality, the reactors are operated at minimum pressure to minimize inventory. M. W. Kellogg did the process engineering and design of this unit.

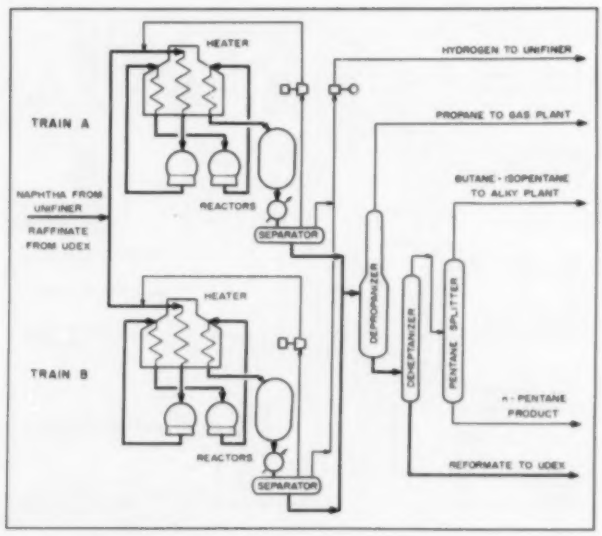
■ The Houdiformer is the world's biggest catalytic reformer, processing 30,000 BPD of desulfurized fresh feed and 15,200 BPD of paraffinic recycle. It produces the refin-

CATALYTIC REFORMER

ery's highest-octane aviation and motor gasoline blending stocks.

There are two reaction trains, consisting of three reactors each. This and other design features permit wide operating flexibility.

Houdry Process Corporation's 3-D platinum catalyst is employed. Houdry also designed the reactors and provided unit heat and material balances.



■ Three primary sections made up this unit . . . feed preparation, Udex extraction, and an aviation gasoline rerun unit.

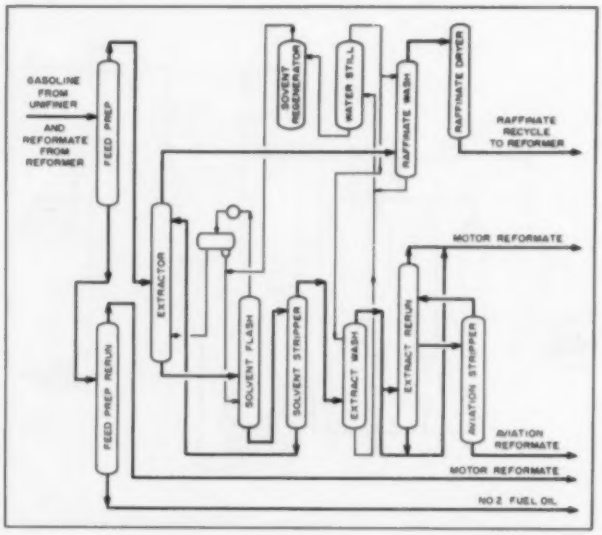
Total feed to the feed fractionation section is 45,000 BPD, including 35,000 BPD of re-

REFORMATE EXTRACTION

formate and 10,000 BPD of heavy catalytic naphtha from Train 3 desulfurizer. The heavier material ends up in motor gasoline and fuel oil, while the lighter stock, 40,000 BPD, is sent to the Udex extraction section where high-octane aromatics are separated from lower-quality paraffins.

Paraffins (raffinate) are recycled to the cat reformer, and the extract is fractionated to provide motor reformate and aviation reformate.

The Udex extraction section, the largest ever built, was licensed and process-designed by Universal Oil Products Company.



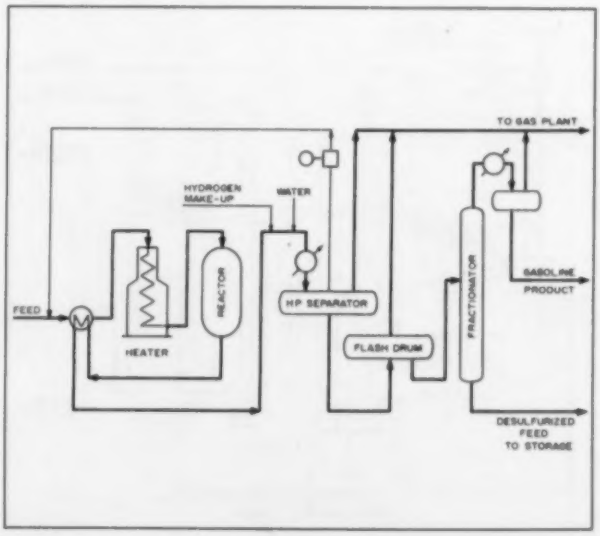
■ Five separate Unifiners employ a cobalt molybdate catalyst to desulfurize and stabilize a total of 88,000 BPD of refinery intermediates as follows:

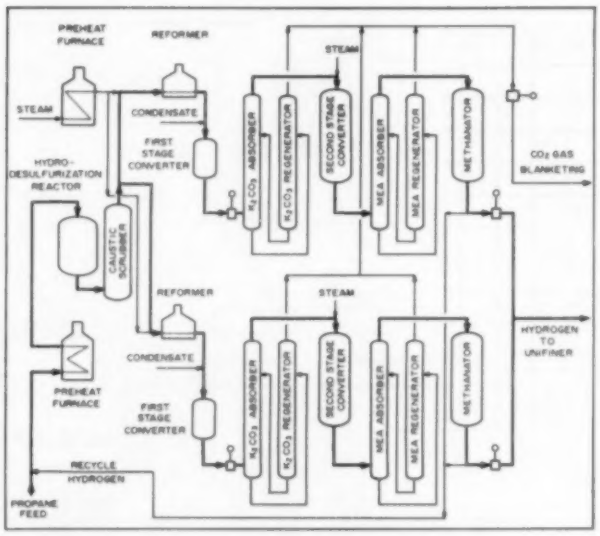
HYDRODESULFURIZATION

1. Intermediate naphtha and coker gasoline fed to the cat reformer.
2. Virgin distillate.
3. Heavy catalytic naphtha.
4. Light virgin gas oil.
5. Light coker and light catalytic gas oil.

Trains 1, 2, and 3 have two series reactors each, Train 4 has one reactor, and Train 5 has two reactors in parallel. Train 5 also includes an amine scrubber to remove H_2S from recycle gas.

Having the highest combined capacity of any HDS unit in the world, the process design was supplied by Universal Oil Products Company.





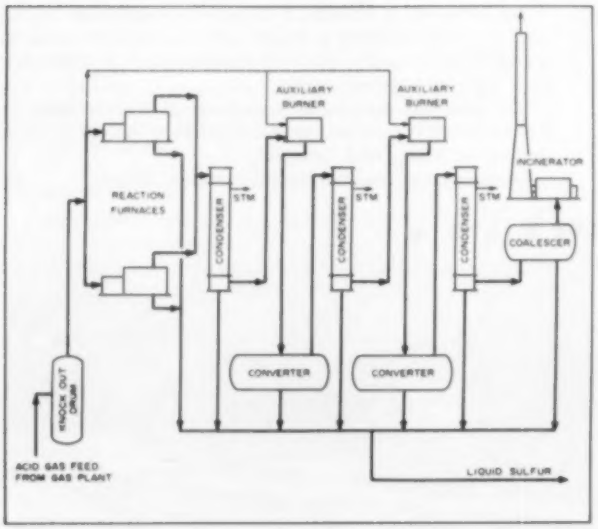
■ This plant is designed to provide as much as 30 million SCF/D of H_2-rich gas to the HDS unit. It's designed, of course, to supplement H_2 supply from the cat reformer.

HYDROGEN PLANT

For maximum flexibility there are two parallel units that convert propane and steam into hydrogen and carbon monoxide and dioxide. Propane is the only suitable feed available right now, but the unit can be easily modified to handle either methane or ethane. Refinery gas *per se* can't be used . . . it's nitrogen content is high, would cause catalyst poisoning.

Feed HDS converts propylene in the feed to propane, thus reducing coke-forming tendency; and, sulfur compounds are converted to H_2S that's removed by caustic scrubbing.

The feed pretreating and reforming sections were designed by Girdler Company, the rest of the unit by Braun.



■ Normally producing about 200 LT/D of sulfur from H_2S, the sulfur plant has two burner sections so that total production can be raised to 340 LT/D during extremely high-sulfur crude runs.

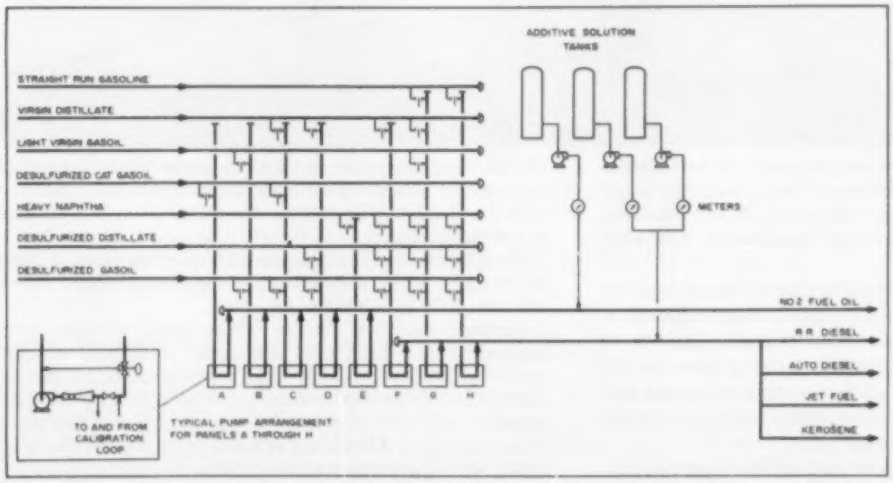
SULFUR PLANT

Reactions in the sulfur plant are:

$$2\,H_2S + 3O_2 \rightarrow 2\,SO_2 + 2\,H_2O;$$
$$2\,H_2S + SO_2 \rightarrow 3\,S + 2\,H_2O$$

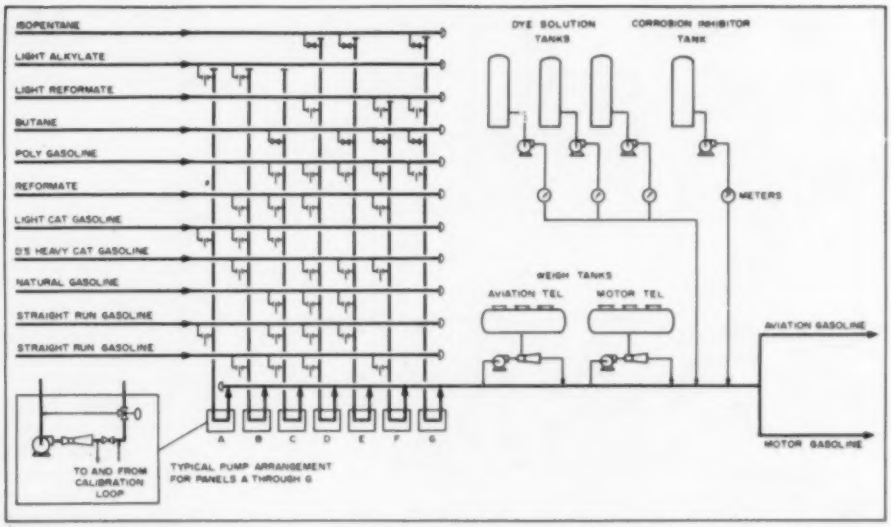
Liquid sulfur is produced in all sections of the plant, is withdrawn through steam-jacketed drain lines. There are two insulated storage tanks that hold molten sulfur for tank truck and tank car shipment.

The sulfur plant was licensed and designed by Ralph M. Parsons Company.



Gasoline Blending

Fuel Oil Blending



Gasoline and Fuel Oil Blending. There are three units used for continuous blending of gasoline and fuel oil products. The gasoline line-blender, rated at 10,000 bbl per hr, can simultaneously blend seven components plus additives.

The No. 2 fuel oil unit handles five components at the same time, is also rated at 10,000 bbl per hr. The third unit blends jet fuels, kerosine, and other distillate products at 4000 bbl per hr.

A complex control system insures continuous product quality. Total output of the blending units is on direct flow control while component flow is on ratio control. A loop calibration system will check each flowmeter and there are limit switches that will shut down the entire blending operation if any operating variable exceeds preset limits.

No. 6 fuel oil is blended in a separate installation. In this unit, vacuum residuum is fluxed with gas oil cutter stock to specification viscosity. Flow of the flux stock is controlled by a recording viscosimeter.

The blending equipment was designed and supplied by Proportioneers, Inc., and the lead handling system by E. I. duPont de Nemours & Company.

Overall design and construction was by Braun.

On the Water Front . . .

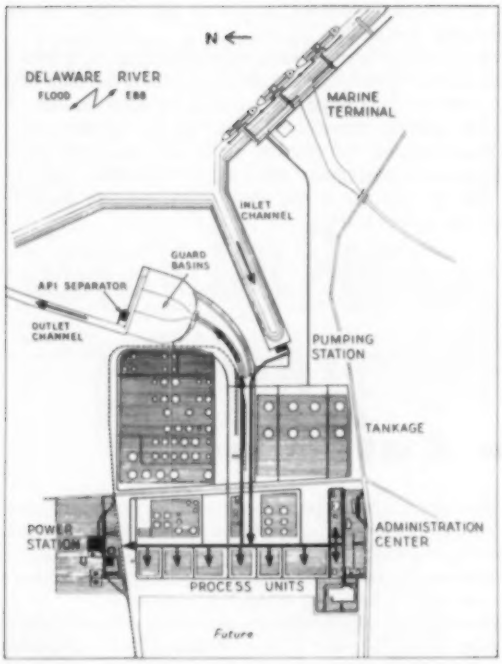
All crude oil and most of the refinery products are handled at the marine terminal. Its facilities include tanker and barge berths, loading and unloading equipment, a slop handling system, and an office for marine department and port officials.

The picture shows a tanker discharging a load of crude at one of the three T-headed piers, while a barge takes on a cargo for delivery up the river in the Philadelphia area. A steel tower on each pier cradles a bank of as many as 11 hoses on roller supports that allow each hose to extend and retract smoothly. An air-powered winch atop each tower positions the hose at the ship's nozzles.

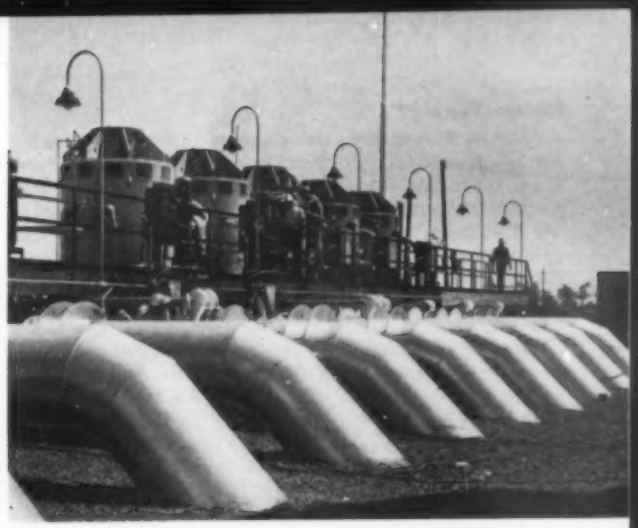
The center and left hand piers will handle tankers up to 68,000 tons. Crude can be handled across either pier, while as many as nine products flow across either the center or right hand piers. The pier to the right serves T-2 tankers and smaller vessels.

More than 14-million cu yards of silt were dredged from the river to make a 400-ft wide approach channel and a 1500 by 4000 ft turning basin.

Onshore facilities include office space, fire-protection equipment, and equipment and tanks to dispose of oily-water ballast and spills. A large pipeway connects the refinery tanks with the marine terminal. Concrete sleepers support more than 25 miles of pipe, ranging from 4-in. up to 30-in. The 30-in. line moves as much as 25,000 bbl per hr of crude from tankers to receiving tanks.



Flow pattern for cooling water. The water travels five miles to and from the Delaware River. Inasmuch as the water temperature varies from 35 to 85 F, a great deal of flexibility is built into the system.



These nine 2000-hp pumps can supply 275,000 gpm of saline cooling water to the refinery. Chlorine is added to the water at this point to minimize growth of algae and slime.

Utilities Systems

Water Systems

Four separate systems are used to satisfy the cooling and process water requirements of the refinery and the adjoining 50,000 kw generating station. The largest system will supply as much as 275,000 gal per min of brackish river water for the refinery's coolers and condensers. Deep wells drilled at the plant site are used to supply drinking water, raw water, and treated water.

The flow pattern for the process cooling water system is shown on the accompanying diagram. This one-pass system, designed to remove a heat load of more than 3 billion Btu per hr, was selected as being the most economical. Detailed studies had shown that a closed system incorporating cooling towers and operating on either well water or river water would be more costly to construct and operate.

Water is pumped from the mile-and-a-half-long intake channel through the refinery by nine 2000-hp pumps, each rated at 34,400 gal per min. Two 78-in. diameter concrete pipes carry the water to the refinery process area. It returns through twin 84-in. lines to three guard basins. Each basin is 600-ft long, 300-ft wide, and 8-ft deep. One basin handles storm water while the other two skim off oily water from the process cooling water.

Oily water is then passed through an API-type separator and the oil returned to the refinery. Clear water from the guard basins and API separator flow through an outlet channel to the river.

Well-water is treated at the refinery to provide drinking water, raw water for miscellaneous purposes, and boiler feed water for the power station and the CO boiler at the fluid coking unit.

Power Generation and Distribution

A power station adjacent to the refinery, owned and operated by Delaware Power and Light Company, provides all power and most of the steam demands of the refinery. Tidewater provides fuel oil, gas, and fluid coke for firing the boilers, also owns the Delaware power-operated boiler feedwater treating plant. (The power station was engineered, designed, and built by Braun, concurrently with the refinery.)

Three boilers, each rated at 500,000 lb per hr of superheated steam at 1300 psig and 950 F, are provided. Designed for operation on fluid coke, the burners will also handle refinery gas and fuel oil. Two boilers will carry the normal full steam load and power requirements of the refinery; the third is a spare.

The two turbine-generators are 25,000 kw, 3600 rpm extraction-condensing units. Design maximum throttle flow is 750,000 lb of 1250 psig, 950 F steam per hour for each unit. Minimum extraction rate for each at full rating is about 400,000 lb per hr.

Each generator is rated 32,000 kva, at 85 percent power factor with hydrogen cooling at 30 psig. Generator output is 13.8 kv, 60 cycles. Capacity can be expanded; provision has been made for addition of another turbine-generator.

Initial operation of the refinery requires about 40,000 kw. This load is divided among six 13.8 kv switchgear buses leaving the power plant. There are a total of 27 underground feeders to refinery substations and one overhead feeder to the waterfront terminal.

About two-thirds of the power is distributed through nine spot network substations that step down the 13,800-v current for powering 2300-v motors in the refinery. Fourteen 13,800 to 480-v secondary selective load center substations handle the remaining third of the power demand. Each station has two 750,862 kva transformers and each has a number of 300 kva and smaller transformers for supplying some 440-v motor control centers and switch racks. There are also two radial-type 750 kva substations.

Switchgear is indoors. Each of the 14 switch houses are pressurized, with the bus ducts entering the houses from the outdoor transformers vapor-sealed as a safety precaution. In addition to containing both 2400 and 480-v substations and several 2300 and 440-v motor control assemblies, most of the switch houses also contain instrumentation and provide shelter for maintenance and operating personnel.

Steam Supply*

Most of the refinery's steam supply is provided from the extraction-condensing turbines at the Delaware Power and Light generating station. There are, however, several supplementary sources within the refinery. Steam generated in the fluid coker's CO boiler and the steam generators that cool reactor effluent make this unit a large net producer. Product and intermediate coolers at several other process units also generate steam. And, the sulfur plant is a net steam producer.

Demands for 600 psig steam vary from as low as 300,000 lb per hr to as much as 800,000 lb per hour. And, power demands may vary from a low of 18,000 kw to a peak greater than 40,000. To absorb fluctuations, the power station is built with great flexibility, has a 69 kv transmission line connected with DP&L's system that either receives surplus power or provides additional power to the station bus, all automatically controlled.

A main header plus necessary manifolds distribute steam throughout the refinery. If steam at less than the 600 psig header pressure is desired, pressure is reduced on-site. A condensate system, primarily supplied by the big steam turbines powering the cat cracker air blower and gas plant gas compressors, and similar units at the fluid coker, returns more than 50 percent of the total makeup-water requirements to the power station.

*References — W. C. Cauthen, C. F. Braun & Co., "Power and Steam for the Delaware Flying A Refinery," American Institute of Electrical Engineers, Summer General Meeting, San Francisco, California, June 25-29, 1956.

C. W. Boice, C. F. Braun & Co., and S. R. Durand, Allis-Chalmers Manufacturing Company, "Power Distribution at Tidewater's Flying A Refinery," Allis-Chalmers Electrical Review, Fourth Quarter 1956.

Contract Maintenance Cuts Costs*

Most maintenance at the Tidewater refinery is on a contract basis. The contractor provides manpower for general labor, turnarounds, permanent supplemental force, and many of the management functions. Tidewater does have a small management force, consisting of a manager and an area coordinator for each of the three areas into which the plant has been divided. In addition, there is an instrument engineer, an electrical engineer, and a corrosion inspector in each area.

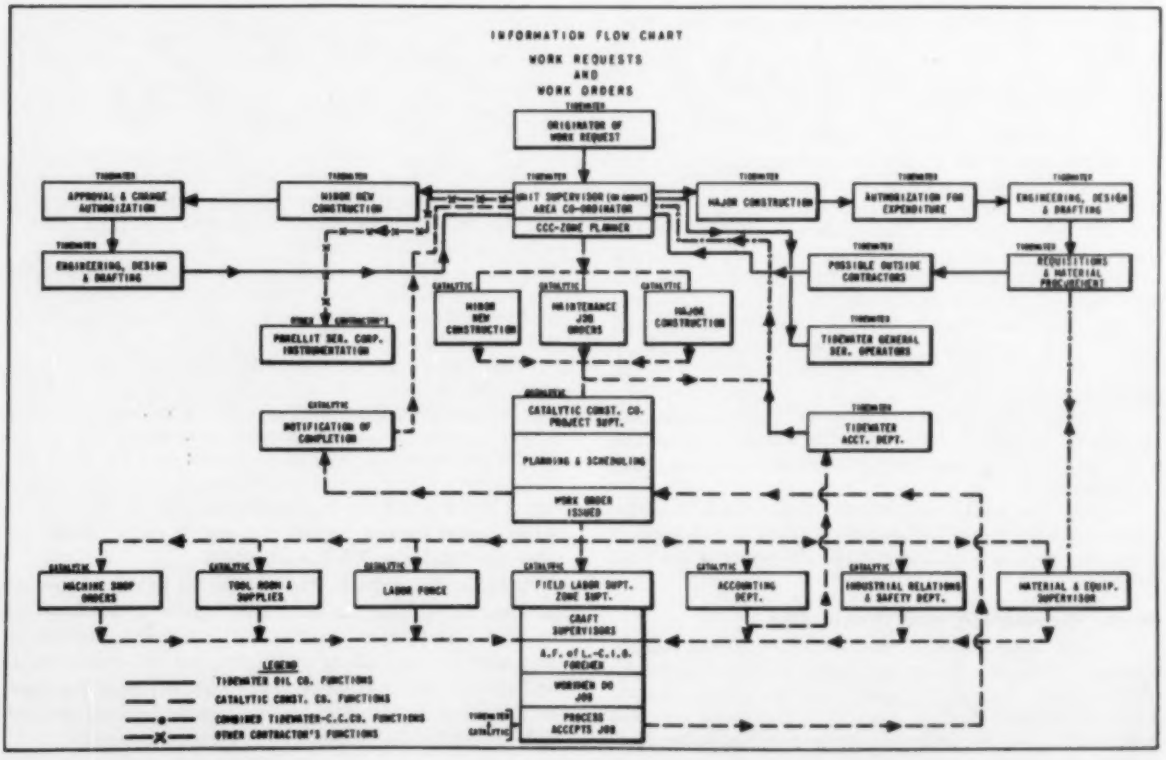
All other functions, except for instrument maintenance, are handled by the maintenance contractor, Catalytic Construction Company, as shown on the work flow chart. Panellit Service Corporation is responsible for instrument maintenance and repair.

Catalytic handles the planning, estimating, scheduling, and supervision of field work. Engineering service is provided by a project manager, a general field supervisor, and three area superintendents supported by a planning and coordination group and by a staff of craft supervisors. Catalytic also operates the machine, pipe, boiler, automotive, sheet metal, and steel fabrication shops for Tidewater.

Employment of qualified craftsmen of the AF of L building trades union permits use of a fluctuating manpower supply. This is one of the biggest advantages for the contract maintenance program: Maintenance workers are on the job only when needed.

Cost analysis and control is facilitated, too. Catalytic submits a job cost estimate upon request, and has a billing system that's organized to provide Tidewater the actual cost for carrying out any given project.

*Alan McCone, Catalytic Construction Company, "Economics of Contract Maintenance," ASME Semi-Annual Meeting, San Francisco, California, June 9-13, 1957.



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OIL WELLS

Note the excellent control of weeds and grasses around this wellhead from just one application of "Telvar."

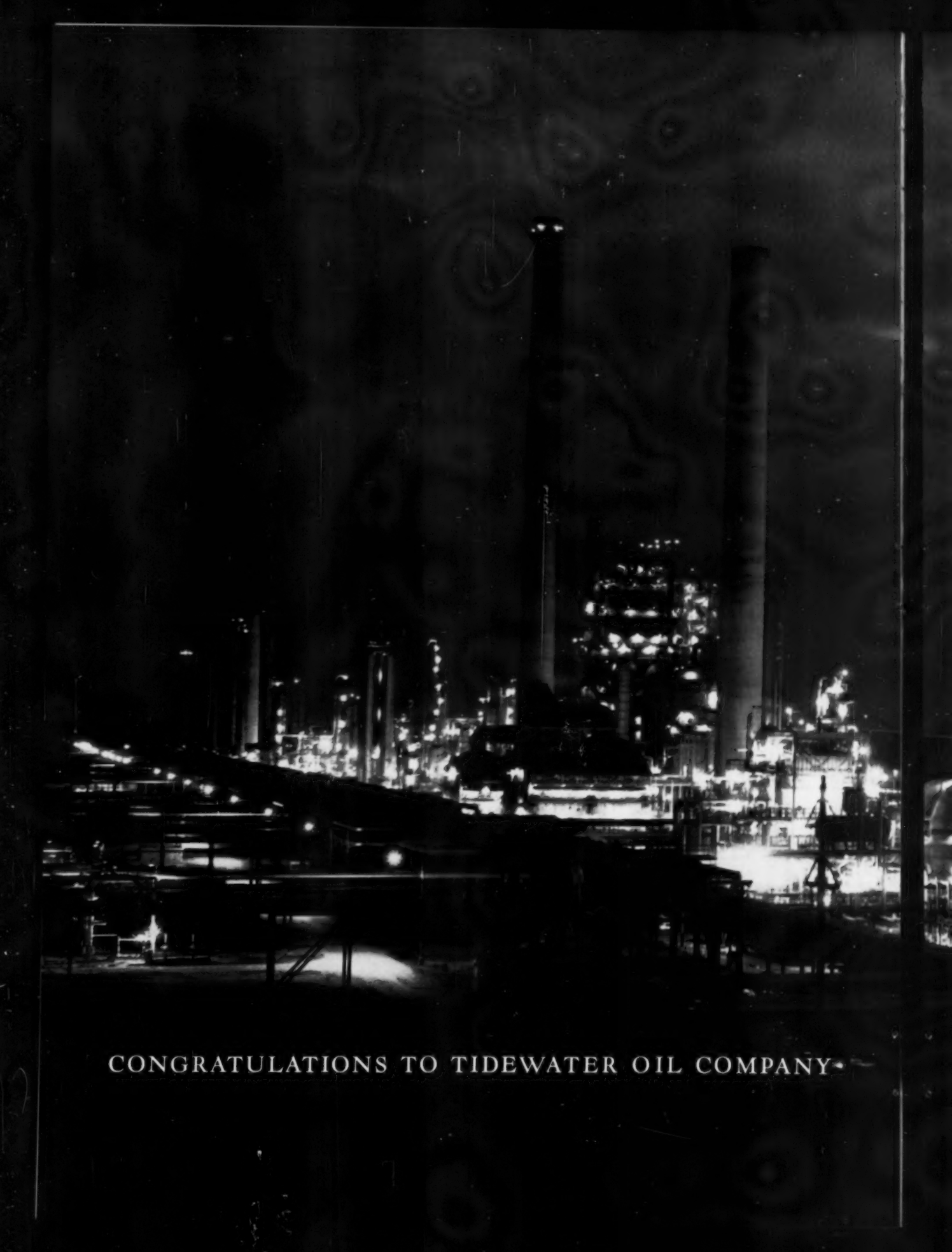
TANK FARMS

The treated area around this tank farm has remained weed-free for an entire season.

PIPELINES

Along these pipelines, where maintenance is tough, one application of "Telvar" has kept the treated area weed-free for a year.

On all chemicals, follow label instructions and warnings carefully.



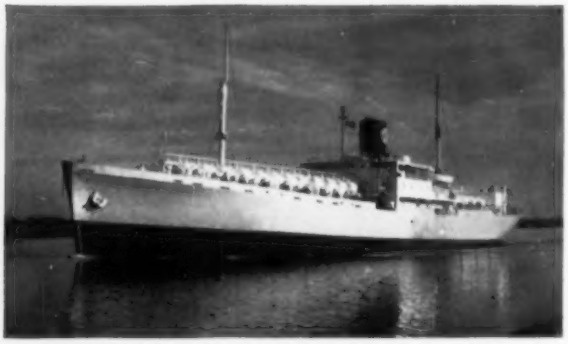
CONGRATULATIONS TO TIDEWATER OIL COMPANY

ON THEIR DELAWARE REFINERY
Engineered and constructed by C F BRAUN & CO

BETHLEHEM AT BEAUMONT

The Nation's Leading Builder and Converter of Waterborne L.P. Gas and Ammonia Vessels

S.S. Natalie Warren, converted to L.P. Gas Carrier. Water capacity 38,000 barrels.

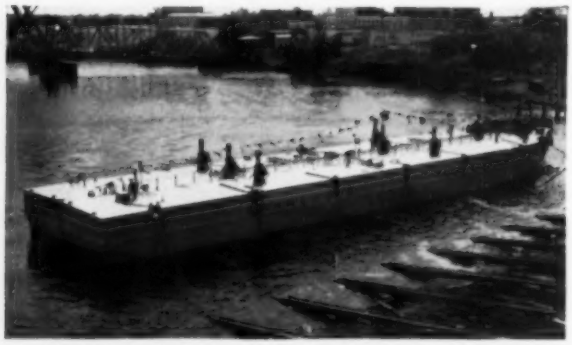


S.S. Ultragaz, converted to L.P. Gas Carrier. Water capacity 17,100 barrels.

Ammonia Mariner, seagoing Anhydrous Ammonia Barge. Water capacity 721,270 gallons.

Esso Viru, oceangoing L.P. Gas Barge. Water capacity 220,000 gallons.

Panama City, rivergoing L.P. Gas Barge. Water capacity 393,000 gallons.



Port Everglades, oceangoing L.P. Gas Barge. Water capacity 550,000 gallons.

These craft are indicative of Bethlehem's activities in the construction and conversion of specialized vessels for the economical and dependable waterborne transportation of L.P. Gas and Anhydrous Ammonia. If you have a problem involving the shipment of these or other petro-chemical products, we may be able to help you. Your inquiries will receive prompt attention.

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Sparrows Point, Md. — Beaumont, Texas
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The many types of equipment used for "lifts" show up clearly in this picture, taken just a few months before completion of the refinery. The tall stack, second from the right, identifies the Delaware Power and Light station. The farmland in the left background is refinery property being farmed under lease by Seabrook Farming Corporation.

Construction Highlights

Building the Tidewater Delaware Flying A Refinery, complete with its general facilities units and power station, stands as the largest such construction project in the history of the petroleum processing industry. Five hundred engineers and coordinators teamed up with 10,000 craftsmen to build the plant.

Incidental to the work, they moved 17 million cu yards of earth, placed 120,000 cu yards of concrete, and erected 9000 tons of structural steel. They installed miles of railroad spurs and roads, a marine terminal for supertankers, and a water system large enough to supply Greater Philadelphia. Yet these were but the trimmings, secondary to the business end of the refinery — the 11 large process units. In these units, erection crews set 1500 pieces of major equipment, electricians installed 400 miles of light and power circuits, and pipefitters fabricated and erected 30,000 pipespools, hooked up with 100,000 valves ranging up to eight feet in diameter.

Rapid completion of the project took a combination of a large and efficient organization, the best of equipment, and a vast amount of prejob planning. Long before the work got underway, engineers, schedulers, materials coordinators, and construction men were busy figuring how to get the enormous quantities of material and equipment to the right spots at the right time.

Two blueprint machines were kept busy, turning out 30,000 prints a week during the peak of planning and construction activities. The drawings varied in size up to the 20-ft flow diagram coming out of the machine above. A week's output, including construction drawings, specifications, and work schedules, would have made a 75-ft stack of paper, weighing 1250 pounds.

The refinery grows. In the foreground is a section of the catalytic cracking unit. In the background is the beginning of a 7-million barrel tank farm.

Getting Vessels to the Job-Site

The project managers decided to ship major vessels to the site as large prefabricated sections, rather than to field-fabricate the vessels piece by piece. Before the sections were made, construction engineers had to determine the largest sizes that could be shipped to the site by truck, railroad, or barge. The final choice of transportation for most of the sections was by barge. This method permitted the fabrication of sections far larger than could be shipped by highway or rail.

Fabricators along the eastern seaboard built the sections of major vessels and large complete fractionating columns for shipment by barge. An old railroad pier at Delaware City was rebuilt to receive the heavy loads. Two 200-ton floating cranes at the dockside worked together to swing the vessel-sections onto big low-bed trailers. Then the loads started their three-mile haul to the job site — usually an "uneventful" trip through narrow city streets, around tight corners, under power lines, and down country lanes, with the vessel sections as big as a house, completely blocking normal traffic.

Erection of Major Equipment

The engineers spotted four of the world's largest guy-derricks at strategic points. They also provided a pair of rugged steel gin-poles that could be shifted about the site where

Dredging for construction of the tanker berths. Dredges like these also prepared a two-mile long channel to the main channel of the Delaware River. Material dredged from the river bottom was used to reclaim nearly 500 acres of marshland adjacent to the river.

needed. And they counted heavily upon the workhorses of the project, a fleet of 130 mobile cranes, ranging from 25 to 60 tons in capacity. Hundreds of heavy trucks, scores of tractors and trailers, and a dozen diesel hoists, rounded out the rigging equipment.

Rigging crews used the three 200-ton and one 150-ton guy-derricks primarily to assemble the tremendous process vessels in the fluid coker, the crude unit, and the cat cracker. They reeved and strung nearly 70 miles of wire rope for load-lines and guy-lines on the four derricks. To reach the top of the coker unit they mounted one derrick on a 135-ft high steel tower, putting the top of the derrick mast at about the height of a 30-story building, 320 ft above the ground.

The two husky gin-poles did yeoman service in spots beyond the derrick's reach. They set 25 of the large columns in one piece, including one 365-tonner, the heaviest such two-pole lift on record.

With the job in full swing, the mobile cranes were on the go from morning to night, making thousands of lifts ranging from light pumps and pipespools to towers as heavy as 75 tons. Sixty-ton crawler cranes, alone or paired, did the heavy work, while pneumatic-tired truck-mounted cranes handled the lighter loads.

Meeting Requirements for Concrete

A modern concrete batch-plant at the jobsite produced more than half the concrete placed on the project—rated at 40 cu yards per hr, it turned out 71,000 cu yards. Local ready-mix companies supplied the balance. On a typical day as many as 30 transit-mix trucks scurried back and forth delivering concrete from the batch plants to the points of use.

Pipe Fabrication

Pipespool fabrication, a major part of any refinery-construction job, reached fantastic proportions on this project. The refinery's huge maintenance shop was finished early in the job and completely outfitted by Braun as a pipe-fabricating factory, with automatic welding facilities and overhead load-handling equipment. Turning out a thousand pipespools per week on one shift, it was unmatched in capacity by any shop in the world during its brief lifetime.

Communications

To insure prompt communications over a site that covered hundreds of acres with some areas, such as the Marine Terminal, as much as three miles away from headquarters, the construction forces used two-way radios in field cars and trucks. Rigging crews passed signals over walkie-talkies and sound-powered phones to coordinate tensioning of long derrick guy-lines.

Recruiting Personnel

The manpower pool in any big industrial area would feel a severe strain when required to supply 10,000 men of more than 20 different crafts to a single jobsite. The Delaware Valley was no exception. Braun's personnel recruiters scoured the New York, Philadelphia, and Baltimore areas for scarce crafts, such as electricians and pipefitters, and managed to meet their manpower quotas. Pipe welders were in such short support that Braun operated a welding school at the jobsite and trained some 400 qualified pipe welders during the project.

But successful recruiting didn't end the personnel staff's problems. Ten thousand men at work on a single construction site create other problems through sheer number. Every morning 4000 automobiles converged on the job's 30-acre parking lot like a crowd going to a football game, creating a traffic snarl at highway intersections. State police established one-way roads to speed traffic flow, and provided signal lights at critical terminals.

In every way, the magnitude of the project created problems never before encountered in the process-construction industry, but they were solved by alert engineering, backed up by teamwork between the owners, the engineers, the construction superintendents, and the subcontractors and craft unions — all of whom contributed to the successful completion of Delaware's new landmark. ★ ★ ★

Putting on the finishing touches. The large building in the foreground is the refinery's mechanical shop, used as a pipe fabrication shop during plant construction.

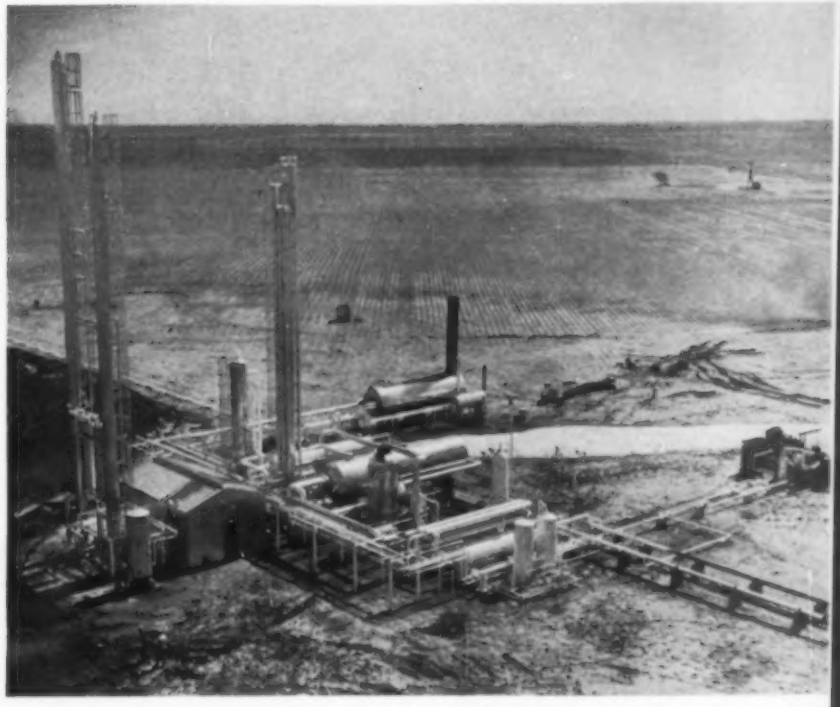


FIG. 1. Excelsior Oil Corporation's new 50-million cu ft per day gas processing plant at Tyrone, Oklahoma. The plant uses a 200-ton ammonia absorption refrigeration unit to chill incoming gas to 0 F for separation of gas liquids, is one of the first low-temperature gasoline plants to be so equipped.

Whit Downer
Associate Editor

Ammonia Absorption Refrigeration Selected For Gasoline Plant

An old refrigeration principle is applied to modern gas processing practice as a means of reducing maintenance costs and increasing operating flexibility

AN old refrigeration principle was applied to modern gas processing practice when a 200-ton capacity ammonia absorption system was selected for a new low-temperature liquids recovery plant at Tyrone, Oklahoma. There were several reasons for choosing an absorption refrigeration system. Some of the more important were low maintenance cost and simplicity and flexibility of operation. The only moving component in the system is an ammonia liquor pump. Widely varying loads are automatically handled with no mechanical adjustments required. Power requirements are directly proportional to the refrigeration load. Refrigeration capacity and efficiency remains high at temperatures down to minus 40 F.

Owned and operated by Excelsior Oil Corporation, an affiliate of Kansas Nebraska Natural Gas Company, Inc., the plant went onstream for the first time on February 11, 1957, has operated continuously since March 20, 1957, except for a brief shutdown during the howling blizzards that enveloped the Oklahoma Panhandle at the end of March. The plant was designed and erected by Black, Sivalls & Bryson's Oilfield Division of Oklahoma City. It is designed to process 50-million cu ft of gas daily. Liquid recovery, based on the total available in the incoming gas stream is: Propane 19 percent, butanes 47 percent, and 14 RVP natural gasoline 95 percent. This corresponds to a total liquid recovery at design gas throughput of 25,800 gal per day, including 8600 gal of propane, 7500 gal of butanes, and 9650 gal of natural gasoline.

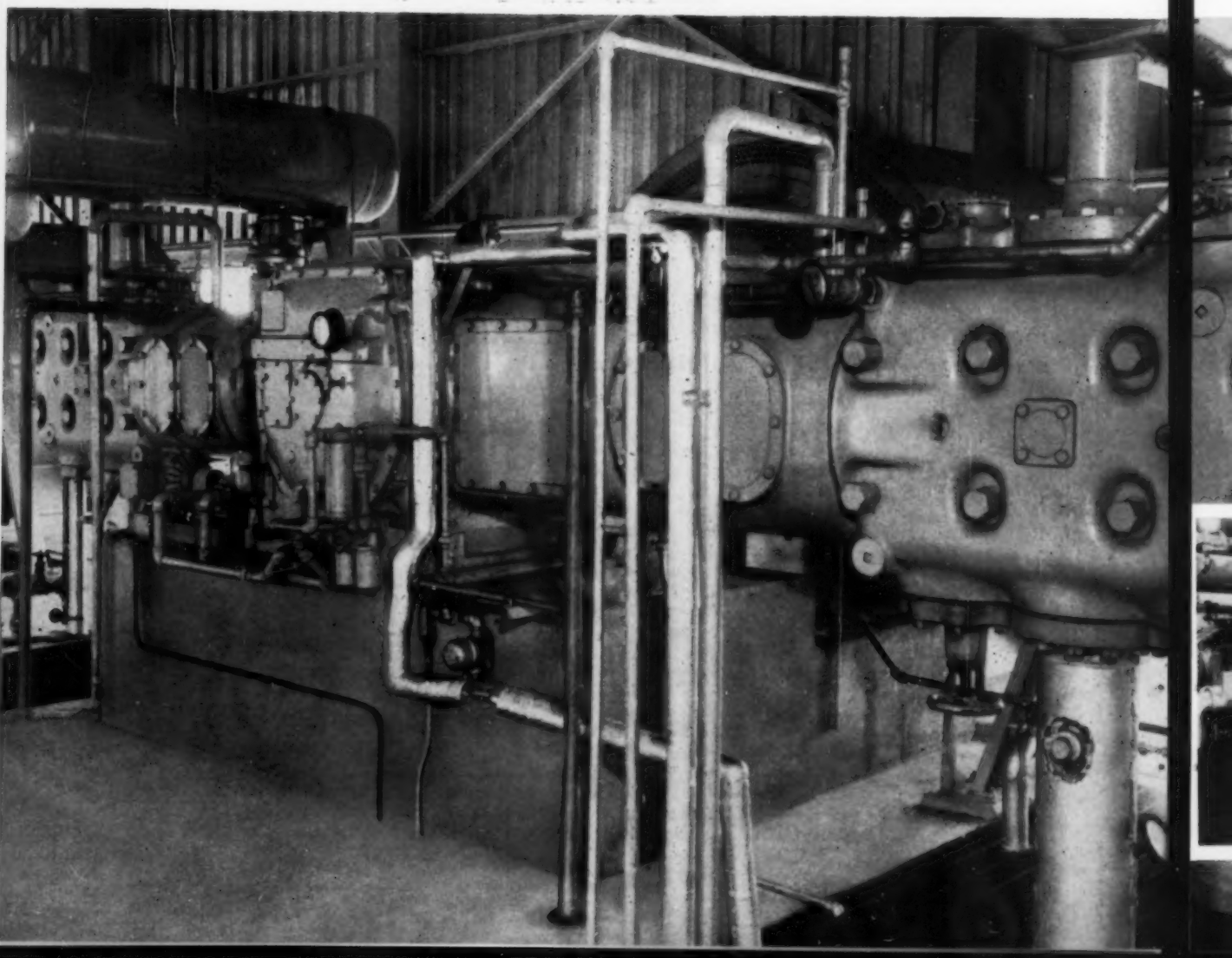
Incoming gas is lean, having the following composition:

	mole %		mole %
Nitrogen	3.05	Isobutane	0.32
Methane	86.80	Butane	0.85
Ethane	5.16	Pentanes	0.33
Propane	3.30	Hexanes +	0.19

Low Temperature Separation of Gas Liquids

Here's how the gas liquids recovery section of the plant operates: Incoming gas enters a freewater knockout drum where entrained water is separated and sent to the burn pit. A syphon and baffle arrangement in the vessel permits any condensed hydrocarbon to be carried out with the gas stream. The gas stream, at about 70 F and 835 psig,

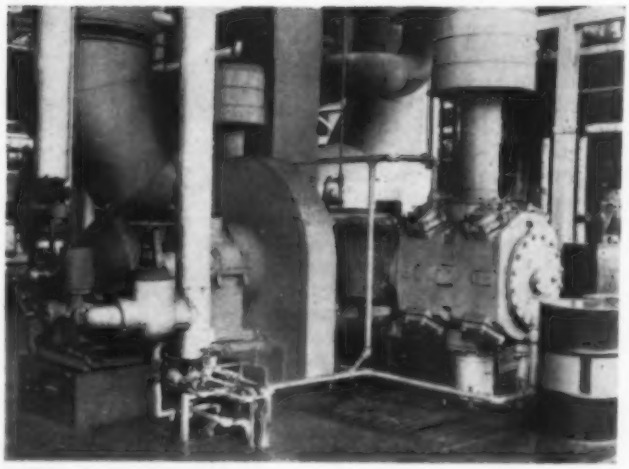
Cooper-Bessemer



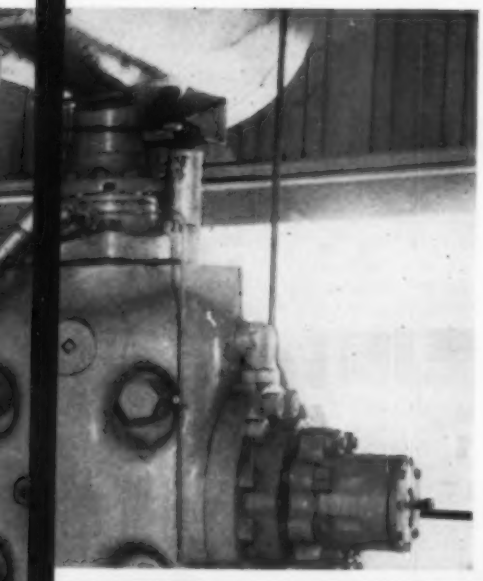
▲1 This 2-cylinder FM compressor, steam turbine driven, supplies aeriation air for this new Tidewater installation.

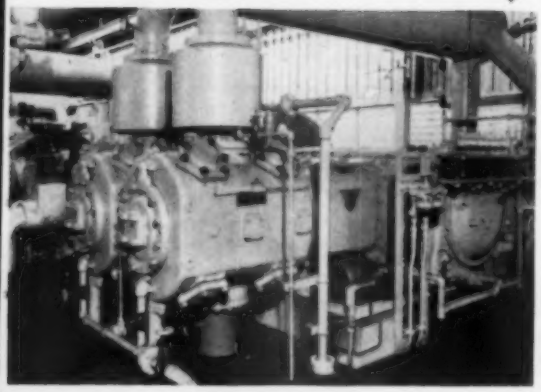
▲2 To maintain absolute purity in hydrogen compression, this compact motor-driven FM is equipped with non-lubricated cylinders.

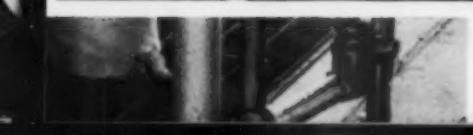
▲3 Handling industrial air requirements for Tidewater's Delaware refinery . . . three 4-cylinder Cooper-Bessemer compressors,—one synchronous driven and two steam turbine driven.



FM Compressors







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then enters the tube side of the residue gas-rich gas heat exchanger, is chilled to about 22 F by the residue gas stream. A hydrate inhibitor is injected just ahead of the heat exchanger in order to tie up water entering the plant in the vapor phase to prevent hydrate formation.

The rich gas leaving the exchanger enters the chiller where it is further cooled to 0 F by boiling liquid ammonia.

Cold gas and condensed liquid leave the chiller and enter a low temperature separator where condensed hydrocarbons and hydrate inhibitor are separated from the gas. The cold residue gas passes from the separator through the shell side of the residue gas-rich gas heat exchanger, and leaves the processing plant at about 60 F and 810 psig.

The condensed hydrocarbon liquid and hydrate inhibitor in the bottom of the low temperature separation vessel are warmed to about 70 F for partial de-methanization. The hydrate inhibitor is separated from the condensate in the low temperature separator and discharged to a regenerator. The warmed condensate is discharged from the low temperature separator to the fractionating system.

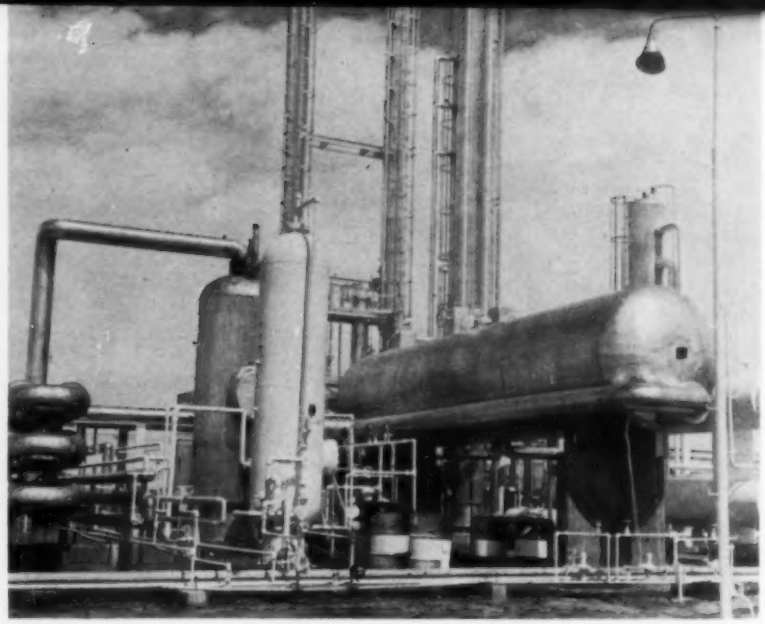

FIG. 3. Heart of the Tyrone gas processing plant. The low-temperature separator is the larger vertical vessel in the center and the large horizontal vessel to the right is the gas chiller. The horizontal vessels at the far right are the ammonia absorber (top) and the ammonia condenser (bottom). The tower in the right background is the ammonia fractionator.

Fractionation Section

Condensed hydrocarbons from the low temperature separator are heated by exchange with natural gasoline and butane products, and are fed partially vaporized to a deethanizer. An overhead partial condenser built into the top of the deethanizer tower is cooled with boiling liquid ammonia to supply adequate ethane reflux for efficient ethane-propane separation. The deethanizer operates at about 500 psig, with overhead gas leaving at a temperature of + 10 F.

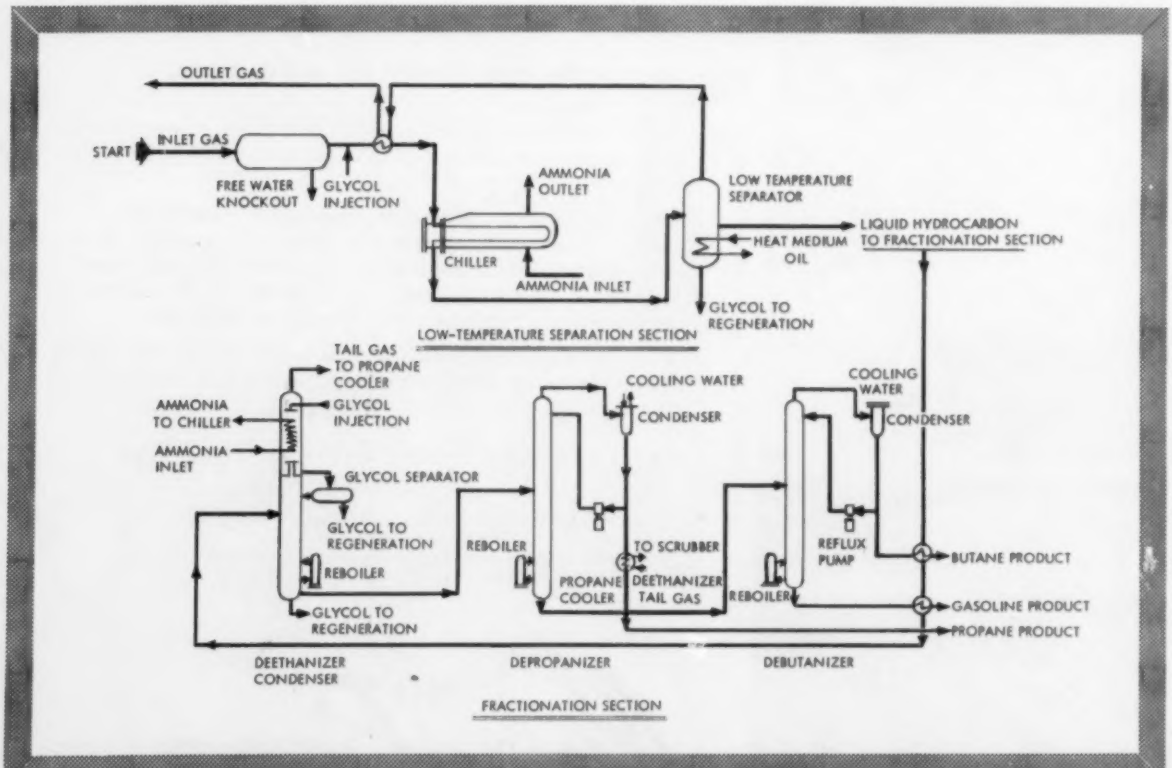

FIG. 2. Process flow diagram for the Tyrone plant. About 95 percent of the C_5-plus natural gasoline is recovered from the incoming gas stream, while butane recovery is about 47 percent and propane recovery about 19 percent. The planned addition of low-temperature absorption, thus making the Tyrone plant a combination unit, will further increase butane and propane recovery.

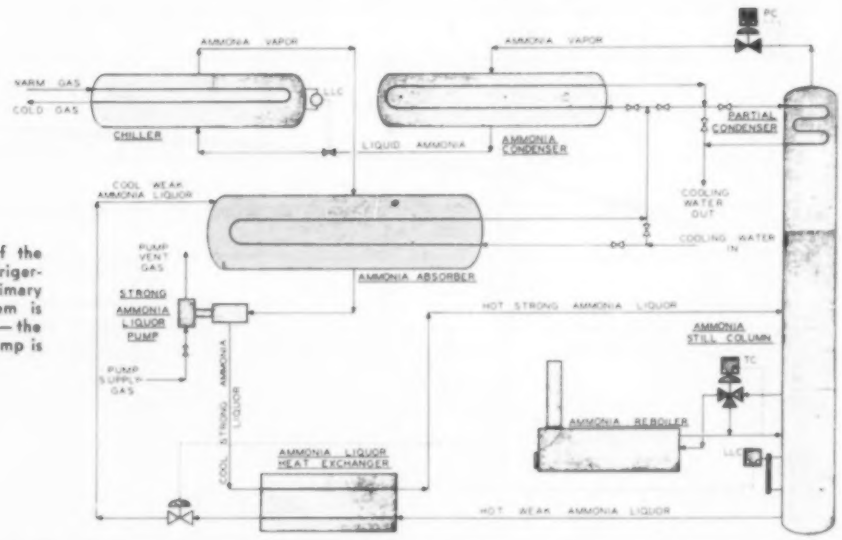

FIG. 4. Flow diagram of the ammonia absorption refrigeration unit. One of the primary advantages of this system is low maintenance cost — the strong ammonia liquor pump is the only moving part.

Refrigeration in the overhead gas from the deethanizer cools the depropanizer bottoms. The pressure in this gas is then used to drive expanding gas reciprocating pumps and provides plant fuel. Deethanizer bottoms feed to a depropanizer and a debutanizer in series for separation of propane, butane, and natural gasoline. The liquid products are shipped from the plant both by railroad and trucks.

All process heat for the plant is supplied by an indirect salt bath heater through which heat transfer oil is pumped to pick up heat for the fractionator re-boilers, to provide heat to the bottom of the low temperature separator, and to heat the control and pump house.

Ammonia Absorption Refrigeration System

As mentioned, the incoming rich gas stream is cooled to 0 F by passing through a coil in an ammonia chiller. The heat transfer coil is totally immersed in boiling ammonia at 9 psig, which corresponds to −10 F. Vaporized ammonia flows to an ammonia absorber where it is contacted with a lean ammonia-water solution that is sprayed into the vessel. A unique arrangement of cooling tubes assures good vapor-liquid contacting. The heat of absorption is removed by cooling water passing through the absorber tube bundle.

Rich ammonia liquor from the absorber is pumped through a heat exchanger where it is warmed by hot lean liquor from the bottom of the ammonia fractionator. The ammonia is separated from the water in the ammonia fractionator, with partial reflux provided by an internal cooling coil. Overhead ammonia, about 99.9 percent pure, flows through a back pressure control and is liquefied in a condenser. The liquid ammonia then flows to the ammonia chiller by liquid level control, a small side stream is also sent to the partial condenser at the top of the plant's deethanizer.

As the flow diagram (Fig. 4) shows, heat is supplied to the ammonia still by a reboiler, in this case, a separate coil in the indirect salt bath heater. Hot lean ammonia liquor from the bottom of the ammonia still is cooled by incoming feed, filtered (not shown on diagram), and re-enters the spray headers at the end of the ammonia absorber.

Control of the Refrigeration System

Control of the ammonia absorption system is relatively simple and is quite flexible. Here's how it works. The temperature of the ammonia in the chiller is a function of the pressure maintained upon it. This pressure can be lowered by speeding up the pumping rate of the rich solution from the absorber, which in turn sends more water through the ammonia still and back to the spray headers in the ammonia absorber. More ammonia is therefore absorbed, reducing the pressure — and

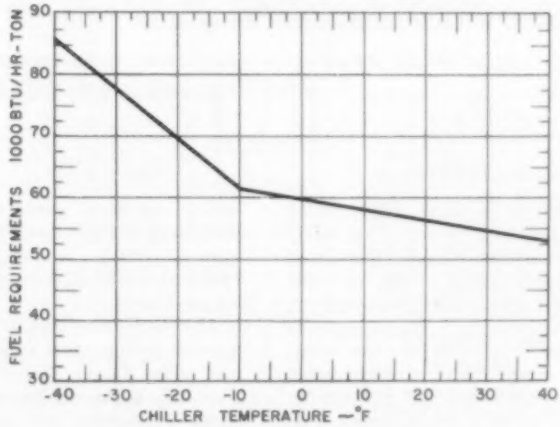

FIG. 5. Heat requirements for the ammonia reboiler are a function of load and desired chiller temperatures. As can be seen, fuel requirements are proportional to the load imposed on the system at normal operating conditions of -10 F and below.

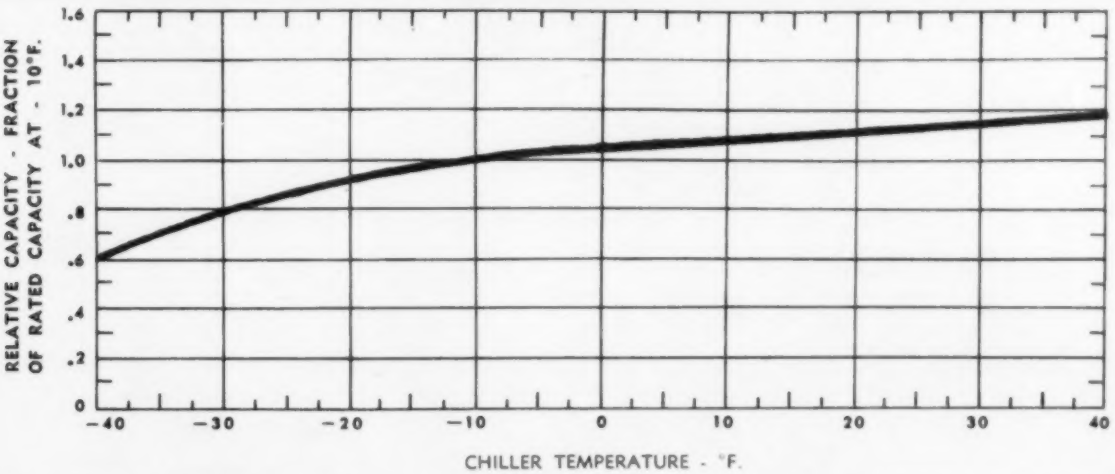

FIG. 6. Operating flexibility with only a small sacrifice in capacity is an important feature of ammonia absorption refrigeration. For example, this chart shows that a unit designed for -10 F operation still has 79 percent pf design capacity when run at -30 F.

temperature—of the ammonia in the gas chiller.

Temperature of the ammonia in the chiller is used to actuate the strong ammonia liquor pumping rate at the Tyrone Plant.

Since a gas-powered reciprocating pump is used to pump the strong ammonia liquor, the flow rate is controlled by a valve on the supply gas to the pump. Other controls include a liquid level controller—expansion valve on the ammonia line to the chiller, and a liquid level controller on the still bottom. A pressure controller regulates still pressure, while a temperature controller on the reboiler circuit regulates still bottoms temperature.

As is made obvious from the above relationship, energy input to the system is supplied by the small liquor pump and fuel gas used for providing reboil heat to the ammonia still. The liquor pump requires about 2.6 std cu ft per min of gas per ton of refrigeration, based on 100 psi gas; if electric powered it will require 1.0 kwhr per ton, based on a 0.8 power factor. Cooling water requirement is about 7 gal per min per ton, based on 85 F water supply. Fuel requirements for the ammonia reboiler vary with chiller temperature ranging from 30,000 BTU per hour at −10 F to 42,000 BTU per hour at −40 F per ton of refrigeration (12,000 BTU per hour) as shown on Fig. 5.

Energy Balance in Ammonia Absorption Refrigeration.

The energy balance for the absorption process is given by the equation . . (1)

$$\left[\begin{array}{l}\text{Heat absorbed by ammonia in chiller}\\ +\\ \text{Heat added to liquid in the still}\\ +\\ \text{Energy delivered to fluid by pump}\end{array}\right] = \left[\begin{array}{l}\text{Heat rejected by ammonia in condenser}\\ +\\ \text{Heat rejected by solution in absorber}\\ +\\ \text{Net loss of heat from fluid due to imperfect insulation}\end{array}\right]$$

Advantages of Absorption Refrigeration

Lower maintenance costs and greater operating flexibility are claimed for ammonia absorption refrigeration plants. Experience at Tyrone has shown that the system is quite versatile from the standpoint of control, having operated smoothly at 40 percent of design as well as at design conditions. As Fig. 6 illustrates, fuel gas requirements are proportional to load; a 50 percent reduction in load means a 50 percent reduction in fuel gas required.

Another advantage, if needed, is that capacity drops only slightly with decreased operating temperature. As shown on Fig. 6, a unit designed for −10 F operation would still have 79 percent of design capacity when operated at −30 F. A compression unit would have only 42 percent under similar conditions.

The mechanical simplicity of the absorption refrigeration system is important to the Tyrone plant. Tyrone is in a sparsely populated area of the Oklahoma Panhandle and maintenance must be performed by the operators. Since the ammonia liquor pump is the only moving part, maintenance isn't much of a problem. Also, slopover of liquid ammonia from the chiller results in only a small temporary change in absorber operating conditions, eliminates concern about liquids getting into suction lines.

The absorption system is constructed entirely out-of-doors—no buildings are needed to protect the equipment. However, an absorption plant does take up more room than a compression plant, which may or may not be a disadvantage depending upon the individual problem.

Cost of Ammonia Absorption Systems

The main difference between the compression and absorption refrigeration systems is the replacement of the compressor by three pieces of equipment: The ammonia absorber, the strong ammonia pump, and the ammonia fractionator. Absorption systems have a relatively high initial cost in small size ranges, (below 50 tons), costing from $700 to $1500 per ton of refrigeration. They are attractive in initial cost in the larger sizes, (over 100 tons), with costs less than $400 per ton for heavy duty completely automatic low temperature refrigeration.

Acknowledgment

The editors are indebted to the natural gasoline department of Black, Sivalls & Bryson for providing data on the Tyrone Plant in general and the refrigeration system in particular. We want to also thank Kansas Nebraska Natural Gas Company, Inc., and its affiliate, Excelsior Oil Corporation for their aid in preparing this article.

1. Barnard, Ellenwood and Hirshfield, Heat-Power Engineering, Part III, pp 1127-32. John Wiley & Sons, Inc., New York City.

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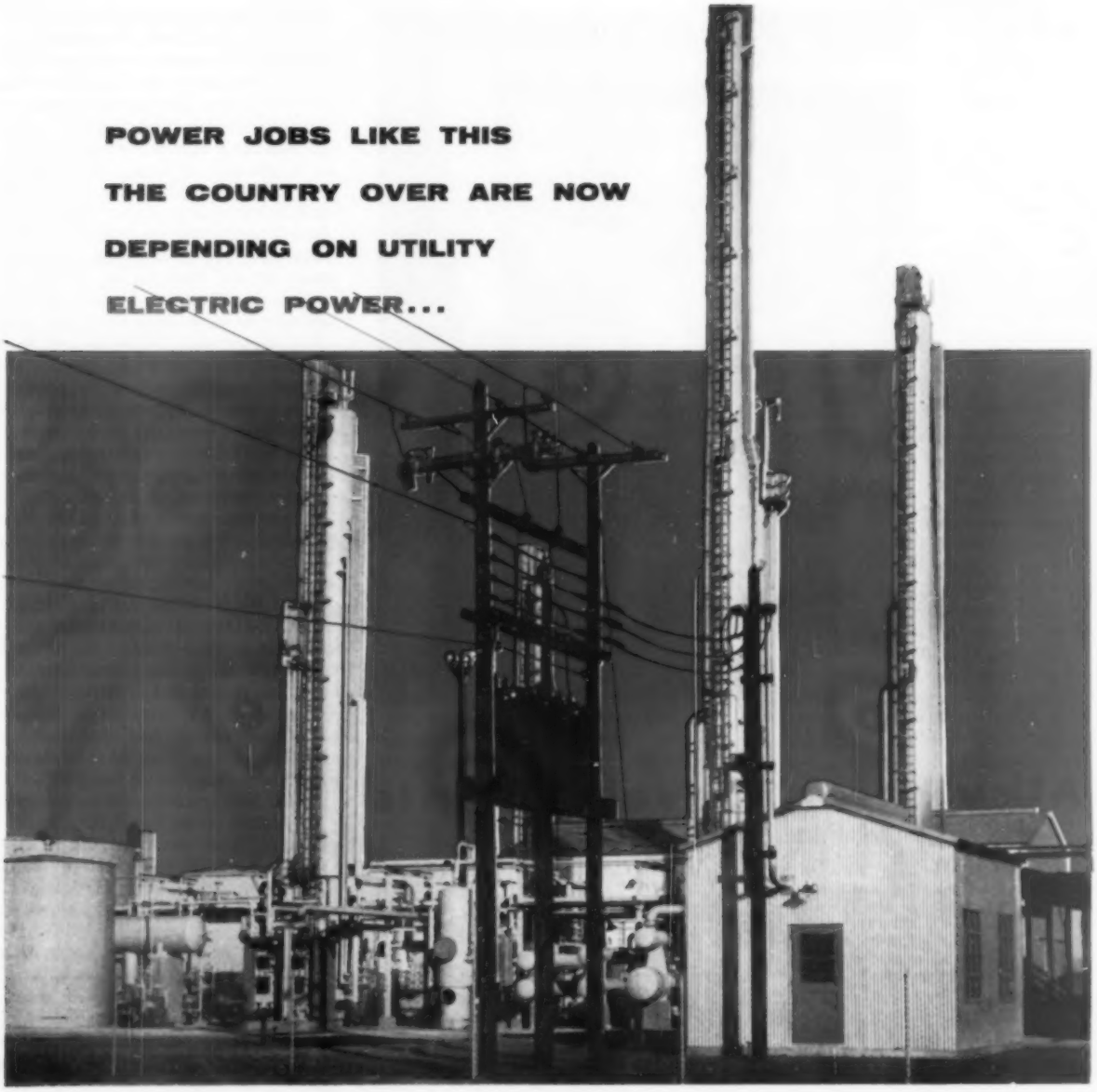

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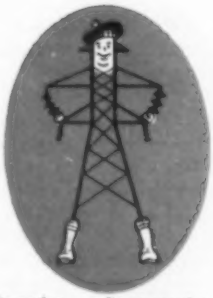

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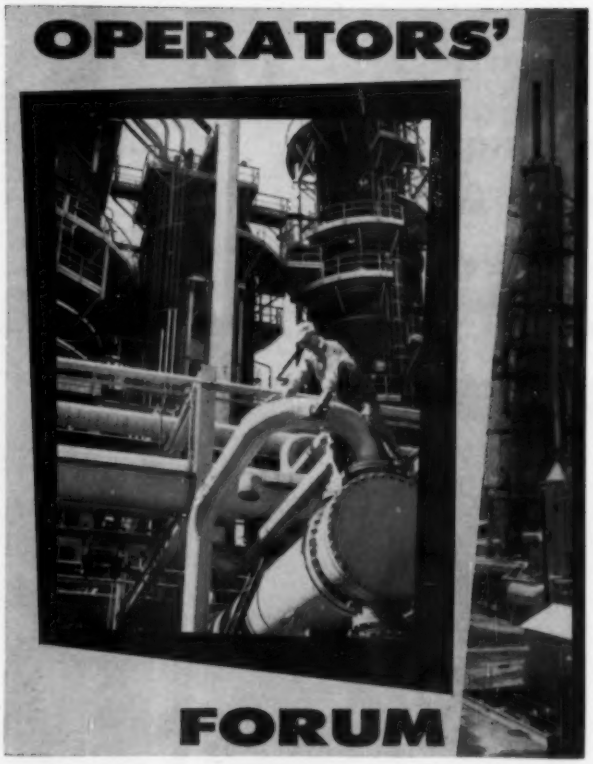

Alkylation Developments

Q Are refrigeration and mixing both being utilized in new HF alkylation units? If so, what is the effect of this mixing on the product quality and yield on both aviation and motor alkylate? How does this affect economics?

A Although perhaps not obvious, mixing and refrigeration in alkylation are closely related. Refrigeration is used to control the overall temperature and to keep it at a reasonable and economic level. Mixing and circulation, such as is obtained with a Stratco contactor, serve, among other things, to control the local temperature and to prevent hot spots or an appreciable temperature gradient. We know that as the temperature is increased there is more tendency for side reactions to occur which result in poorer quality and higher catalyst consumption. It was found in the early H_2SO_4 alkylation work that a low yield of low quality product with a high catalyst consumption could be obtained either by using a high temperature on the order of 100 F, or poor mixing.

Effect of Temperature

Alkylation occurs between isobutane and olefin molecules and the ideal is to keep all molecules at a controlled temperature and not just some spot in the reaction system that is conveniently accessible to a temperature measuring device. If the temperature is allowed to rise where the reaction takes place or an apppreciable temperature gradient is obtained, it is substantially the same as if refrigeration were controlling the temperature at the maximum temperature in the system. As far as the reaction is concerned, the bulk of it probably takes place at the highest temperature present and not at the lowest temperature measured. Calculations have been made which show that if no circulation of the reaction mixture were obtained, and if all of the reaction occurred instantaneously at the point of olefin injection, the theoretical rise in temperature would be in the order of 70 to 80 F. Excellent alkylation results may be obtained with a theoretical temperature gradient in the order of 1 F, and a temperature gradient of this magnitude may be obtained at a reasonable cost.

Effect of Mixing

Mixing is being recommended and is being installed in most of the new HF alkylation units. Apparently considerably less mixing or less energy input is required in HF alkylation than in H_2SO_4 alkylation, and less mixing is currently being provided. One reason that less energy input is required is that the HF reaction mixture is considerably less viscous than the H_2SO_4 reaction mixture. Also, the isobutane is more soluble in the HF catalyst. Even higher concentrations of isobutane in the reacted mix, or higher external isobutane to olefin ratios, are used in HF alkylation than in sulfuric alkylation, so it seems reasonable that the reactions with the two different catalysts are in general controlled by the same variables or follow the same general principles. Thus, it seems reasonable also that mixing should contribute to low acid consumption and high product quality with both catalysts.

It would seem reasonable that without mixing or with less mixing, more favorable conditions, such as a higher isobutane to olefin ratio, would be required to give satisfactory acid consumption and product quality. Or vice versa, if reasonably good mixing is used, it should be possible to ease off on some of the other reaction conditions. Actually this seems to work out in practice.

What Type Refrigeration?

Regarding the use of refrigeration, there seems to be no question but what the product quality improves as the temperatures are lowered from about 90-100 F to 60-65 F, and it seems reasonable that the acid consumption

would decrease when a lower temperature is used. However, the exact temperatures required, or the optimum temperatures, are not as well established in HF alkylation as in H_2SO_4 alkylation, except that temperatures as low as used in H_2SO_4 alkylation apparently are not required. Some of the HF units use butane refrigeration rather than water cooling to avoid the possibility of having the corrosive condition resulting from HF and water, and fairly recently some have been converted to deep well water cooling so that a temperature of around 80 deg or lower may be maintained.

At least two large HF units were converted some years ago to refrigeration so as to be able to operate with a temperature considerably lower than could be obtained with cooling water. This was prompted by the observation that during winter operation considerably higher octane alkylate was obtained. Both of these units also have good mixing. We understand one of the units is operating at about the design rate of production and is making quite high quality alkylate and considerably better than most other units with less favorable reaction conditions. The other unit is operating at least double the design capacity and yet is making alkylate sufficiently high in quality so that the aviation fraction may be blended with isopentane and without toluene to meet specifications for 115-145 aviation gasoline.

Effluent Refrigeration

It seems reasonable to assume that as new HF alkylation units are installed and old ones are converted to increase the capacity and improve the quality refrigeration will be used, since Effluent Refrigeration is applicable to HF alkylation as well as to H_2SO_4 alkylation. By using Effluent Refrigeration high isobutane to olefin ratios on the order of 8 or 9 to 1 may be obtained with only about a ratio of 2½ to 1 coming from the deisobutanizer, and at the same time refrigeration may also be economically obtained to give any desired temperature. In other words, with Effluent Refrigeration considerably lower temperatures may be obtained than with water cooling and at the same time obtain a high isobutane concentration in the reacted mix.

Perhaps it should be mentioned that although the effect of temperature is not as well understood in HF alkylation as in H_2SO_4 alkylation, in general the quality of the product obtained in H_2SO_4 alkylation is higher than that obtained in water cooled HF alkylation and hence as far as quality is concerned there is an incentive to favor the HF reaction by temperature as well as a high isobutane concentration.

Justification for Refrigeration

A quantitative measure of the economics of mixing and refrigeration as related to aviation and motor alkylate may be answered only for a specific case, and even then quite a few assumptions must be made. However, the industry has found in recent years in H_2SO_4 alkylation, and it is particularly true at the present time, that the improved product quality, yield and acid consumption, of aviation and motor alkylate which may be realized with good mixing and adequate refrigeration, and in general by utilizing optimum or near optimum reaction conditions, are well justified economically. To the best of my knowledge, no H_2SO_4 plants are being installed today to make low quality alkylate. High quality aviation alkylate with a Performance No. of around 160 with 4.6 cc of TEL of course requires no toluene and is quite flexible with what it may be blended to meet specifications for 115-145 aviation gasoline. High quality total alkylate has an end point well under 400 F, so all of it may be used in motor fuel without rerunning, which represents an appreciable increase in yield. And with 3 cc of TEL it has an octane value well above 100. So it seems reasonable that the utilization of suitable reaction conditions, such as good mixing and lower temperatures than can be obtained with cooling water, would also be well justified economically for HF alkylation.

Aside from the question of the economics of product quality and yield, many refiners are finding today that competition is forcing them to make just about the best products which it is possible to make. In other words, competition rather than economics is the controlling factor. Accordingly, some now consider the safest procedure is to design for the highest quality alkylate or not far short of it, especially since the differential in capital cost should have a short pay-out period.

A. R. Goldsby
Director of Research
Stratford Engineering Corporation

This question had the experts stumped at the Western Petroleum Refiners Association's recent Question and Answer session, held in El Dorado, Arkansas. Mr. A. B. Goldsby, director of research for Stratford Engineering Company, Kansas City, Missouri, mailed an answer to the WPRA. We thought you'd be interested in it, and with the WPRA's permission have reproduced in OPERATOR'S FORUM.

Removal of Sulfur Salts

Q What, if any, effective method is available to remove heat-stable sulfur salts or compounds from the foul DEA stream in a desulfurizer?
E. P. L.

A Simple distillation is the means generally employed in industrial practice to remove heat stable and non-volatile substances from ethanolamine solutions. The chemical reactions leading to the formation of such undesirable compounds are complex, and a variety of products may be formed. Specifically, it is known that monoethanolamine will react with carbonyl sulfide, which is present in small concentrations in many sulfur-bearing gases, to form diethanolurea, a relatively heat stable compound. Also in the presence of oxygen, sulfur compounds may be oxidized to thiosulfate which forms a stable salt with ethanolamines. In addition, oxygen can form degradation products such as polymers, acids and other non-volatile compounds which will build up in the ethanolamine circulation if not removed.

In most commercial desulfurization units a small kettle-type reboiler is provided to distill continuously a small percentage of the total circulation. Closed steam coils in this reboiler distill a water-ethanolamine mixture into the vapor space of the reactivator column. Impurities including solid matter accumulate in the reboiler and are withdrawn periodically.

If thiosulfate is formed, increased recovery of amines can be realized by adding equivalent amounts of caustic or soda ash to the main circulating stream to break up the stable amine salt. The resulting sodium thiosulfate will be removed by the stripper.

Whitney Weinrich

REFINING IN BRIEF

Maintenance

Organization Factors in the Modern Refinery

Claude H. Trotter
Phillips Petroleum Company

THE purpose of maintenance organizations is to provide optimum maintenance. Optimum maintenance might be defined as spending the minimum in maintenance dollars to achieve maximum profits. This may sound rather narrow at first, however, optimum maintenance should be considered in a broad sense. For example, painting, certain conveniences and other things of this nature which affect employee relations, public relations, and profits are all a part of the program for providing optimum maintenance.

Providing optimum maintenance in the modern refinery is a complex problem. Optimum maintenance today cannot be accomplished by a few relatively simple methods and procedures. The equipment to be maintained is widely dispersed over hundreds of acres in many cases; the equipment varies in a wide range of sizes and costs for the individual pieces of equipment; skill requirements vary in complexity from such simple things as tightening a bolt to the complexities of advanced electronic circuitry; another part of the problem is to determine the right job to do at the right time, with the right people and with the right materials, tools, and instructions. Unit onstream time is extremely critical and can have a drastic effect on profits. In view of these, and many other conditions, the maintenance organization must employ many factors to obtain optimum maintenance.

Our program consists of 14 basic factors which the maintenance organization can employ toward attaining their overall objective of better and more economical maintenance. In our case, these factors are employed to varying degrees, depending upon the size of the plant and other conditions. The aim is to apply each factor to the maximum extent which it is economically justified in each plant.

Through the use of these factors some of the plants have reduced maintenance costs by 25 percent. Others have made slightly better progress. Labor effectiveness has been greatly improved and unit downtime has been reduced.

In our experience the maintenance organization must have the backing of top management. Further, the supervisors must understand and properly apply these basic factors to obtain maximum benefits. There is no substitute for good foremanship and management.

In discussing these maintenance factors, you may find that you are already using some of them. However, you will probably be interested in noting the relation of the factors which you are using to some of the others.

Let's look at these basic maintenance factors.

Control Group

In some of our plants a separate maintenance control group has been established as a part of our maintenance or plant organization. This group, or an individual in some cases, is responsible for the overall control of procedures, for making and analyzing delay studies, for establishing standard job methods, for summarization and analysis of maintenance cost information, for periodic review of the maintenance organization and its objectives, and for other work of this nature.

This is a new development and positive data as to the results achieved are not yet available. We are convinced, however, as are several of the nation's leading industrial companies, that the greatest single reason for the failure of any maintenance system is in not having an individual, or group, responsibile for follow-up checking on the operation of the system.

Condensed by the author from the ASME paper of the same title given before the ASME Petroleum Conference, Dallas, Texas, September 23-26, 1956.

Work Order System

This is the cornerstone of maintenance control. The approval and priority procedures involved in the work order system give control of the work to be done and the timing as to when it will be done.

A written work order procedure is used, requiring that every job be requested on a standard form. Thus, the basic information for equipment records, job analysis, work scheduling and work measurement is provided.

Work orders and their basic principles are also being applied to engineering design and process engineering work.

Job Planning

Using the basic information furnished on the work order a careful analysis is made of the work requested. This function is the responsibility of a separate planning group within the maintenance organization.

In analyzing a work order, it must be determined exactly what is to be done, when it can or must be done, the number of men required by crafts, the length of time they will be required, the sequence in which the job must progress, what materials are needed and what tools and equipment to supply, etc. Then the job can be planned which will result in having the right number of properly skilled men at the job with necessary tools, mechanized equipment, and complete instruments for doing the job when the job is actually ready to be worked on.

Further use is made of the basic work order information in making weekly forecasts. This provides a weekly plan and overall goal for the various departments in the plant.

From the weekly forecast, daily work schedules are made which set forth the next day's work in detail. Each man is scheduled and the schedules for the next day are issued by 2:00 p.m. of the

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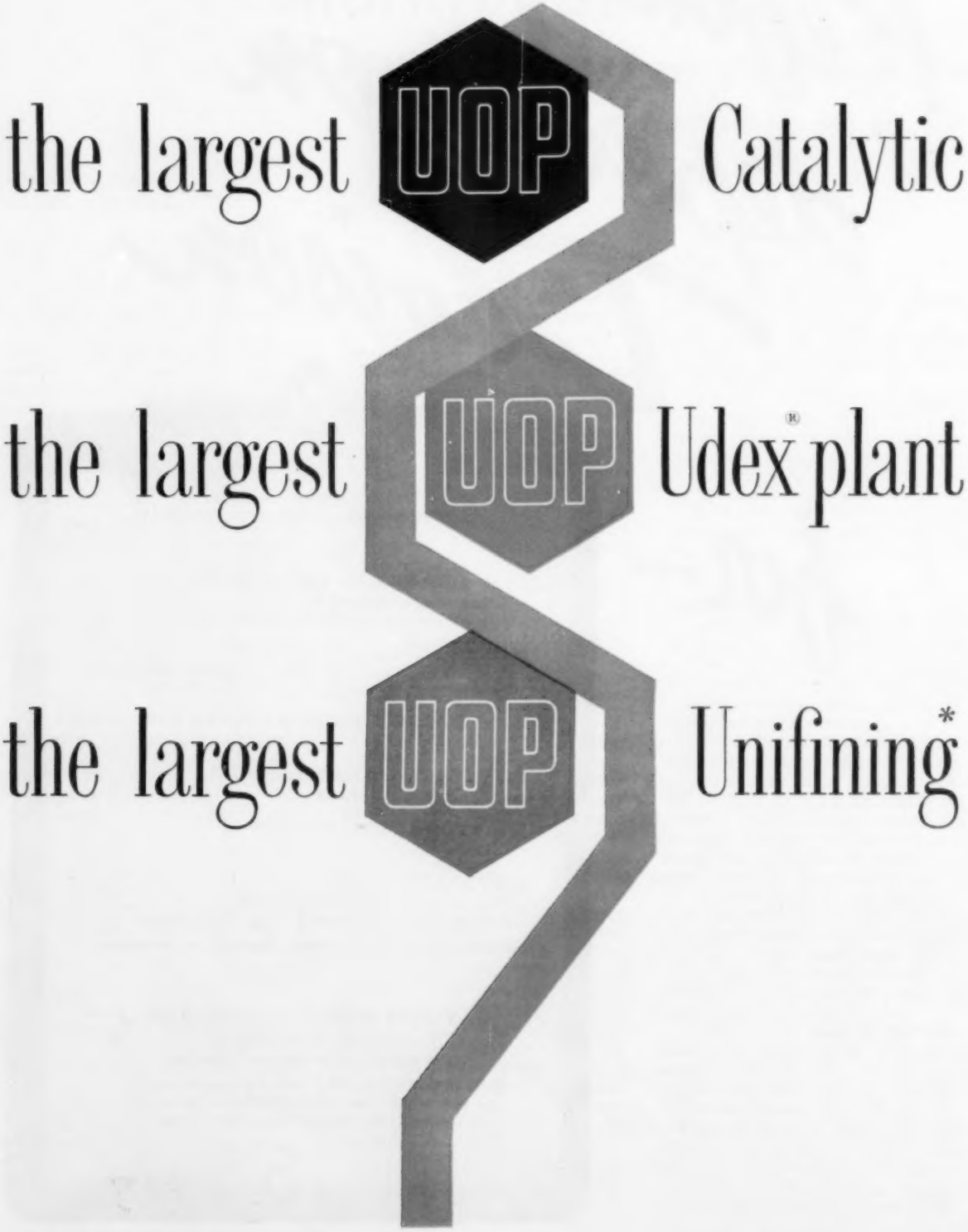

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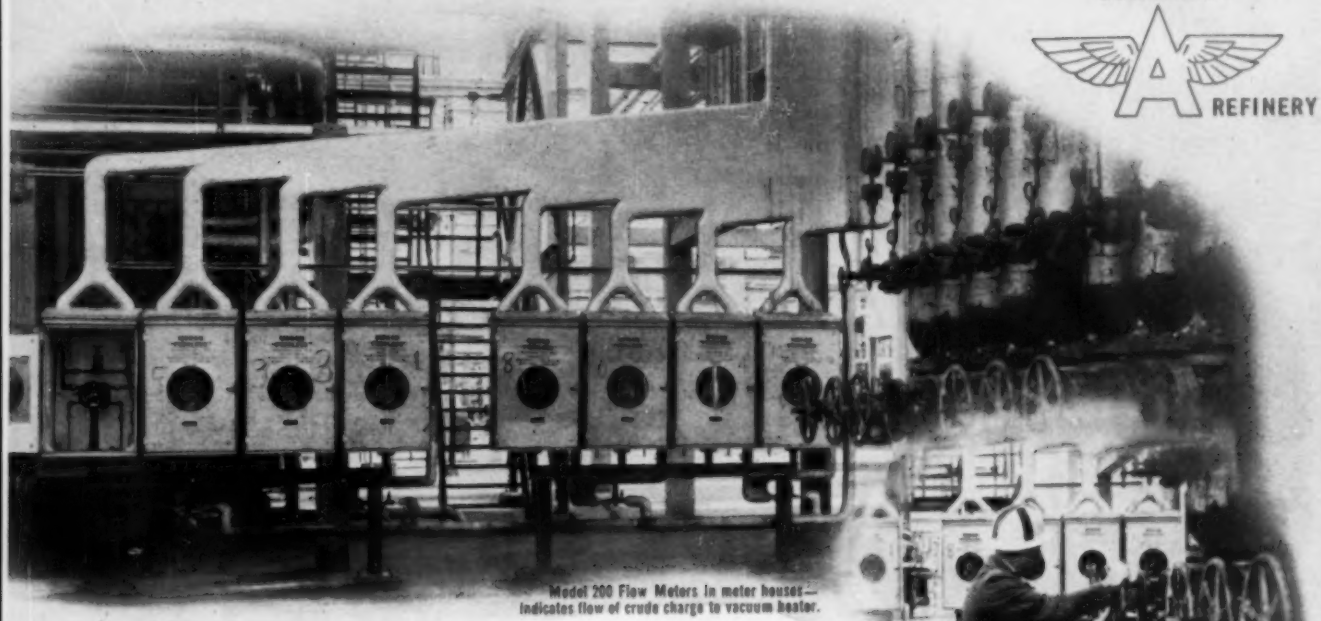

Model 200 Flow Meters in meter houses—indicates flow of crude charge to vacuum heater.

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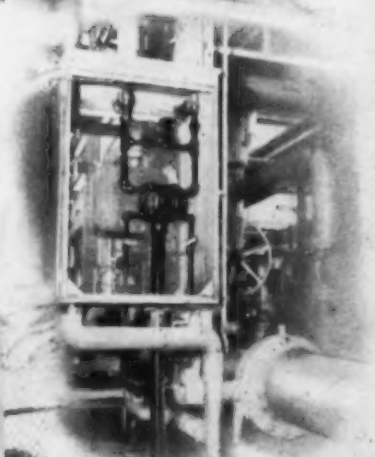
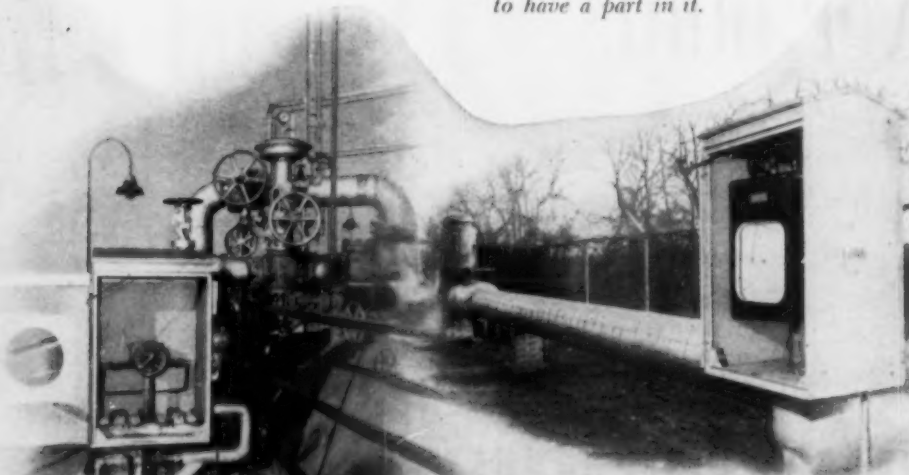


Model 199 Differential Pressure Unit on Taylor Transmitter—measures, indicates and transmits flow of stripping steam to cracker fractionating tower.



Model 202 Flow Meter—records water flow from remote well station.

Model 200 Flow Meter—indicates flow of snuffing steam to cyclone at top cracker regenerator.

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DU PONT *Petroleum Chemicals* NEWS

Number 77 in a Series of Bulletins for the Petroleum Industry

JULY 1957

Sludge problems in residual fuels minimized by Du Pont additive

ASSISTANT GENERAL MANAGER . . . ORCHEM

DR. WILLIAM C. KAY is Assistant General Manager of the Organic Chemicals Department of the Du Pont Company.

He started work with Du Pont as an industrial engineer at the Chambers Works in 1934. He became project engineer in 1939, and joined the neoprene manufacturing organization as chief supervisor in 1941.

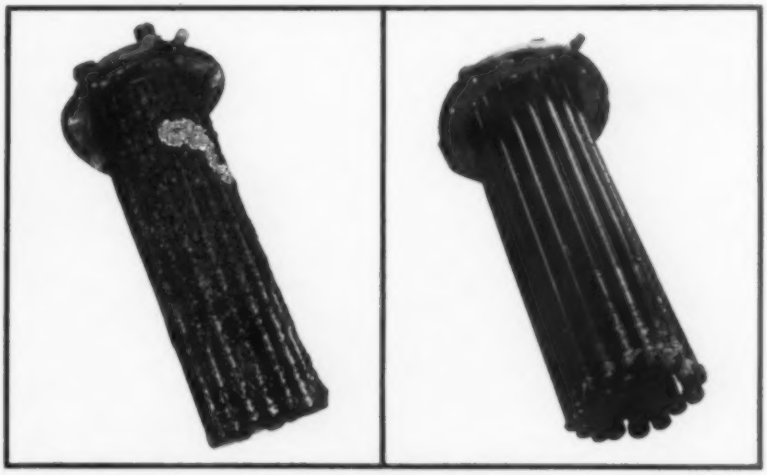
In 1943, Dr. Kay was assigned to the atomic project at Oak Ridge, Tennessee, as production superintendent. From there, he moved to the Hanford Works plutonium project in Washington. He was named Process Manager of the Du Pont Grasselli Chemicals Department in 1947.

Dr. Kay in 1950 joined the Explosives Department as Director of Manufacturing for the Atomic Energy Division. He assumed the same position in the Organic Chemicals Department in 1955. His appointment as Assistant General Manager occurred at the beginning of this year.

Dr. Kay earned his B.S. and Ph.D. degrees, respectively, at the University of Minnesota and M.I.T.

Sludge-packed systems cleaned and KEPT clean

It is, of course, a well-known fact that residual fuels too often cause serious problems. Being the "bottom of the petroleum barrel," they contain, in concentration, all the impurities from the lighter oils which have been distilled off.



PREHEATER TUBE-FOULING . . . solved by FOA-2

TO REVIEW THE PROBLEM . . .

Insoluble sludge is likely to form in residual fuels—in storage, in transit or in use. That, briefly, is problem No. 1.

Problem No. 2: Residual fuels, when blended, are often incompatible. Insoluble sludge is likely to form.

Du Pont Fuel Oil Additive No. 2 solves both problems.

Sludge cure

When sludge forms, trouble starts in the form of clogging. Many times nothing short of costly major "surgery" will start the oil flowing. So tank walls are cut through, sludge is removed mechanically, and the hole is patched up.

Oftentimes it is found that fuel system parts, filters, strainers, nozzles, preheater tubes and shells, have become clogged. While mechanical cleaning sometimes restores their functions, expensive replacements are sometimes necessary.

With these corrective measures going on, *downtime* is mounting, and labor costs are keeping pace.

Many other residual fuel users know that such an operation isn't necessary, that FOA-2 would have cleaned the tanks and parts, restored operation of the system. No cutting into tanks, no cleaning or parts-replacement, no heavy labor expense. Downtime? Greatly reduced.

ADVERTISEMENT—Prepared for the Petroleum Chemicals Division of E. I. du Pont de Nemours & Company (Inc.)

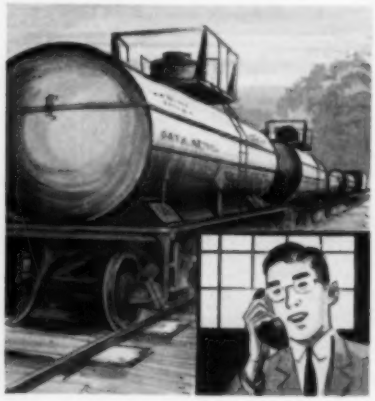
OVER

DUPONT *Petroleum Chemicals* NEWS

Du Pont is always prepared to meet your emergency TEL needs

REFINERY SUPERINTENDENT:

We're in a jam. Our next regular TEL delivery is not due for another 10 days. But our refinery is gearing up to meet an unexpectedly heavy demand . . . and we don't have enough TEL to do the job.



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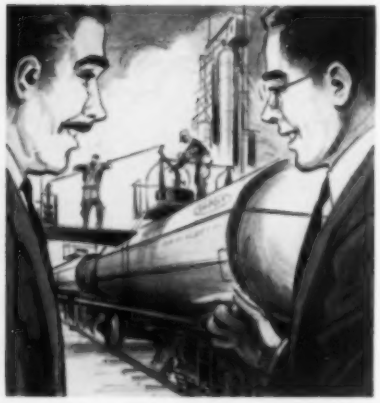
Don't worry about it. We have several tank cars of TEL on a siding only a few miles from here. We can get a couple of cars over first thing in the morning.



REFINERY SUPERINTENDENT:

The TEL cars arrived this morning. That's service . . . less than 24 hours to deliver. It's good to know we can get that kind of service when we need it.

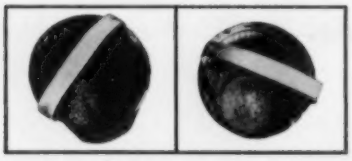
CONTINUED

Sludge problems

How it works

FOA-2 added to residual fuel attacks insoluble sludge, reduces the size of the particles which compose it, suspends them. Thus the fuel flows freely through the system. There is no blockage of nozzles, lines, filters, strainers and other parts. Oil, suspended sludge particles, and the FOA-2 burn completely.

Once a system is cleaned with FOA-2, small amounts of the additive *keep* it clean. That's because FOA-2



STRAINER-PLUGGING . . . solved by FOA-2

is a stabilizer and solubilizer as well as a dispersant.

FOA-2, being nonmetallic, is ashless and leaves no residue after burning.

Case histories prove power of FOA-2

Early this year we assembled in one technical memorandum ten case histories documenting the power of FOA-2 to clean, and to keep clean, systems fueled by "barrel-bottom" residuals.

We believe you will be interested in the ease and economy of using FOA-2, and suggest that you write for Technical Memorandum No. 317, dated January 1957.

NOZZLE-FOULING . . . solved by FOA-2

Director of Petroleum Laboratory Appointed to NACA Subcommittee

Dr. Bernard M. Sturgis, director of the Du Pont Company's Petroleum Laboratory, Deepwater Point, N. J., has been appointed to the National Advisory Committee for Aeronautics subcommittee for aircraft fuels.

Subcommittees of the NACA assist in initiating research programs, advising upon technical problems, reviewing current research throughout the nation, recommending new areas of research, and coordinating research programs. NACA objectives are to anticipate the research needs of aviation and to supply the armed forces and industry with basic information for the design and production of aircraft.

Du Pont's Petroleum Laboratory devotes a considerable part of its research effort to aircraft fuels and lubricants.

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OVER

A-4801

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preceding day. This minimizes delays in getting underway the following morning.

Closely connected with planning and scheduling of maintenance work is the work backlog. Here again the basic work order information is used and a backlog of work can be compiled for each craft. With this information on workload, personnel changes can be made to meet the various situations. Weekly work backlog reports give a current picture of the manpower situation for the next week and for the coming three to four weeks.

Preventive Maintenance

One of the advantages of preventive maintenance is that maintenance can be done when desired rather than when a breakdown requires it. This means that most of the night shift men can be transferred to the day shift when working conditions are better. It also means that manpower can be continually busy on scheduled work rather than in surges which inevitably occur when failed equipment must be repaired. Also, overtime requirements can be greatly reduced under these conditions. Lastly, preventive maintenance will cut down the production interruptions due to emergency failures. In many industries, including refining, this can amount to the largest savings of a preventive maintenance system.

Planned Shutdowns

Planning shutdowns is important to the economy of the plant. Probably the largest savings derived from this work is through minimizing production losses. Due to the extreme concentration of work and people in the shutdown area, confusion often develops on the poorly planned turnaround, and may prolong the downtime several days. The onstream time of some large units is worth several thousand dollars an hour and poor shutdown planning is very costly.

Planning shutdowns also provides better control of workload and prevents cumulative work peaks. It is also an effective means of reducing overtime.

Warehouse or Stores Control

Up-to-date maximum and minimum quantities of various warehouse items are required for good material control. Formulas using this and other basic data can be used to determine the most economical order quantity and order point.

Material delivery must be scheduled so that materials are on the job-site prior to when needed. The use of parts catalogs will minimize delays in obtaining materials on the job-site.

Major Equipment Overhaul

There is usually one best way to disassemble, check, replace parts, and reassemble any large piece of equipment. This is not necessarily the method being used, but the best method can usually be determined by the combined evaluation of engineering, supervisory, and other maintenance personnel. A good procedure can sometimes cut overhaul time in half.

Standard procedures also can be developed for minor repetitive field and shop jobs. Manuals of these standard procedures are desirable for craftsmen such as the pump mechanics, electricians, instrumentmen, and machinists.

Delay Studies

Delay studies determine the effectiveness of the maintenance organization. They are used to determine where and why improvement is needed. We are finding that a large part of our ineffectiveness is due to the inadequacy of management handling. People on the management team don't always function in accordance with the procedures set up by top management because of misunderstandings, lack of information, and resistance to change. We are concentrating on the delay-study-phase of work measurement at present, using our supervisors to help make the studies.

Equipment Improvement

This is a broad program aimed at making equipment easier to operate and maintain. Accessibility is increased, or better material and design are used to minimize the replacement frequency.

Equipment improvement also includes standardization of design where practical. Heat exchangers are an example where interchangeable bundles and heads can be used to minimize spare requirements.

New units are being designed with maintenance in mind. Preventing excessive maintenance begins in the design stages.

Shops and Tooling

This factor is one which has received improvement by almost everyone so little comment is needed except that adequate facilities of this nature show good returns. And, they enable you to work smarter and not harder.

Control by Budget

The budget control factor will work best when the other factors mentioned above have been successfully employed for a considerable period. The foregoing factors pinpoint most of the budget items.

Supervisory Development

It might seem that with the preceding factors and controls, only a limited amount of supervision would be required. This is not the case; there is no substitute for good management and good foremanship. All levels of supervision must be trained to understand and use the maintenance controls. An important part of such training is to emphasize that maintenance controls have the strong support of management.

Training of Hourly Maintenance Personnel

The training program for hourly personnel should be planned as to scope, method, time required, and have detailed objectives. A training manual is a big asset. It shows disassembly procedures, operating tolerances, and trouble shooting techniques.

Tests can be used effectively to show progress to both management and the trainee. Where advancement is involved, tests should also determine the qualifications.

Supervisory participation in the training program is essential to its success. The returns from a successful training program are far greater than its cost.

Analysis of Performance and Costs

Analysis of performance and cost is done on a continuous basis. This is the job of continuing self-criticism. The use of tabulating equipment greatly broadens the field of coverage. With the electronic equipment it is practical to know how much is being spent on individual pieces of equipment and on types of equipment such as pumps, compressors, electrical equipment, piping, instrumentation, etc. With information of this nature available, steps can then be taken to improve the exceptional situations.

While it is not indicated as a separate item in the maintenance organizational factors, it is felt that good human relations are an important part of the program. Although the end results of the maintenance effort usually are applied to physical equipment, these results are obtained through people. Therefore, we can only obtain the best results with good human relations.

In conclusion, it can be said that the successful application of these 14 basic factors will give effective, modern maintenance in the refinery of today. Each of the refinery maintenance organizations plans to utilize the factors to the maximum practical extent as aids toward reaching their objectives of better, more economical maintenance. ★ ★ ★

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Size or complexity makes no difference to the prompt and efficient service that The M. W. Kellogg Company offers to the process industries on heat exchangers. Whether it's an order for a single 14-ft. diameter giant, like the one above, or a group of normal size units, Kellogg's recently expanded facilities are geared to produce to the strictest design standards and delivery schedules. With these facilities, Kellogg can handle the complete job of designing, engineering, and fabricating heat exchangers, or make exchangers to customers' own designs.

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P 816.1

Supercharging adds 33 percent to brake horsepower; scavenging air pumps powered by exhaust gases

Turbocharged Two-Cycle Gas Engines

C. A. Chamberlain
Clark Bros. Company

WHILE the advantages of turbocharging a two-stroke cycle gas engine, namely elimination of parasitic scavenging pump load, higher operating pressure levels with resultant higher horsepowers, and lower specific fuel consumptions, have been known for years, the actual turbocharging of such an engine has been only a relatively recent accomplishment.

In the past, the lower exhaust temperatures inherent in two-stroke cycle operation, coupled with the lack of expansion turbines and centrifugal compressors of an efficiency high enough to meet the air requirements, plus the lack of an adequate and practical means of supplying scavenging air for start up and low load operation, has stymied two-stroke cycle turbocharged engine development.

However, recent development at Clark Bros. Company of high efficiency expansion turbines and centrifugal compressors, plus the development of a hydro-mechanical drive for start up and low load operation of the turbocharger, have made it possible to turbocharge two-stroke cycle gas engines.

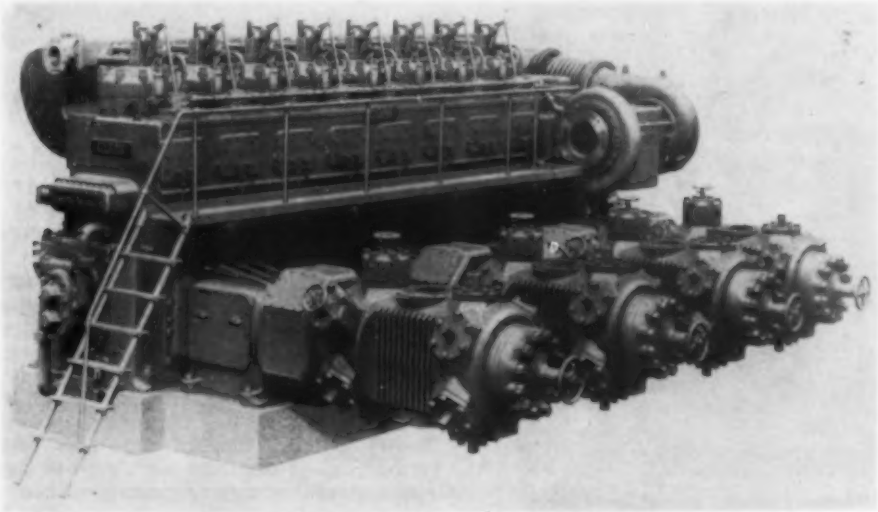
The high efficiency of these components has resulted in an even greater supply of excess air than was available with engine driven scavenging pumps. This additional excess air not only results in more thorough and efficient scavenging of the power cylinders, but also in a high degree of cylinder wall cooling that provides cooler operating surfaces for pistons and rings.

Resulting scavenging air temperatures are no higher than in non-turbocharged units, even though the scavenging air pressures are as high as 7 psi at rated load. At ambient air temperatures above 75 deg and for periods of overload operation, built in scavenging air coolers automatically prevent scavenging air temperatures from exceeding 145 deg. This, coupled with the fact that a compression ratio comparable to that of non-turbocharged engines has been used, means that the compression temperature of the fuel-air charge is no higher than in non-turbocharged units. This means that detonation, which is most directly caused by high compression temperatures, is no more likely than heretofore.

The greater air flow also results in more homogeneous mixing of the fuel-air charge and, consequently, the ability to burn a leaner charge.

Thus, we find, in comparison with a non-turbocharged engine, the same scavenging air temperature, the same compression temperature, a lower combustion temperature, and a lower temperature at the end of the expansion stroke. The end result is a lower cycle temperature. It then follows that the mean cylinder wall temperature must be lower than in a non-turbocharged engine. This has been, in fact, found to be the case. Heat transferred to the cooling water through the jackets of the power cylinders has been found to

*Condensed by the author from the paper given before the Western Petroleum Refiners Association, Toledo, Ohio, May 24-25, 1956.



Clark turbocharged gas engine-driven compressor; the supercharging turbine is shown at upper right.

be 12 per cent less per unit area of cylinder wall despite a brake horsepower increase of 33 per cent.

Power formerly absorbed by the engine driven scavenging air pumps (some 8 per cent to 14 per cent of the engine output) is now being provided by the exhaust gas, a source of energy formerly thrown away as waste. Therefore, the same net horsepower can be obtained with the consumption of less fuel. The result has been the lowering of the specific fuel consumption of the turbocharged engines to 7000 Btu/BHP-hr at rated load.

The other major obstacle, the providing of scavenging air for start up and low load operation, has been overcome with the development of a hydro-mechanical drive. The turbocharger, at start up and low loads, is chain driven from the engine crankshaft through an over-running clutch and a hydraulic coupling. This drive results in a blower speed sufficient to supply the air required. The maximum horsepower required from the crankshaft, which, of course, occurs at no-load conditions when exhaust temperatures are at a minimum, is only a small percentage of the horsepower the blower can absorb. As the load increases and the exhaust temperature rises, the power transmitted through the drive decreases until it reaches zero at about 75 per cent of rated load. At this point a torque sensitive device indicates zero torque being transmitted by the drive and allows the oil to be drained from the hydraulic coupling. This allows the turbocharger to free wheel at whatever speed the engine load demands. Thus, in the operating range between 75 and 120 per cent to 130 per cent of rated load, the trubocharger supplies scavenging pressure and a quantity of air ideally suited to each engine load. The quantity of excess air increases in proportion to the load which results in smooth, even combustion and cylinder temperatures that are nearly the same as those at rated load even during overload operation.

Conversely, as the load is decreased, the turbocharger slows up until at 75 per cent of rated load the hydraulic coupling fills with oil and prevents further deceleration.

To summarize, the turbocharging of the two-stroke cycle gas engine has resulted in a 33 per cent increase in brake horsepower with only a 15 per cent increase in the indicated horsepower. This is the result of the elimination of the parasitic scavenging pump load and higher mechanical efficiency. This increase in horsepower means that on a horsepower basis, foundation requirements are reduced to approximately two-thirds, cooling water facilities reduced approximately 40 per cent and fuel consumption reduced to 7000 Btu/BHP-hr. The detrimental effects of high ambient temperatures and temporary overloads are minimized. ★ ★ ★

REFINING IN BRIEF

P 791.3

Painting Steel Structures In Petroleum Refineries

J. O. Jackson and Joseph Bigos
Vice President, Research & Engineering, Pittsburgh-Des Moines Steel Company
Senior Fellow, Mellon Institute of Industrial Research

Bituminous mastic, applied via hot-spray, is one effective protector of outer surfaces.

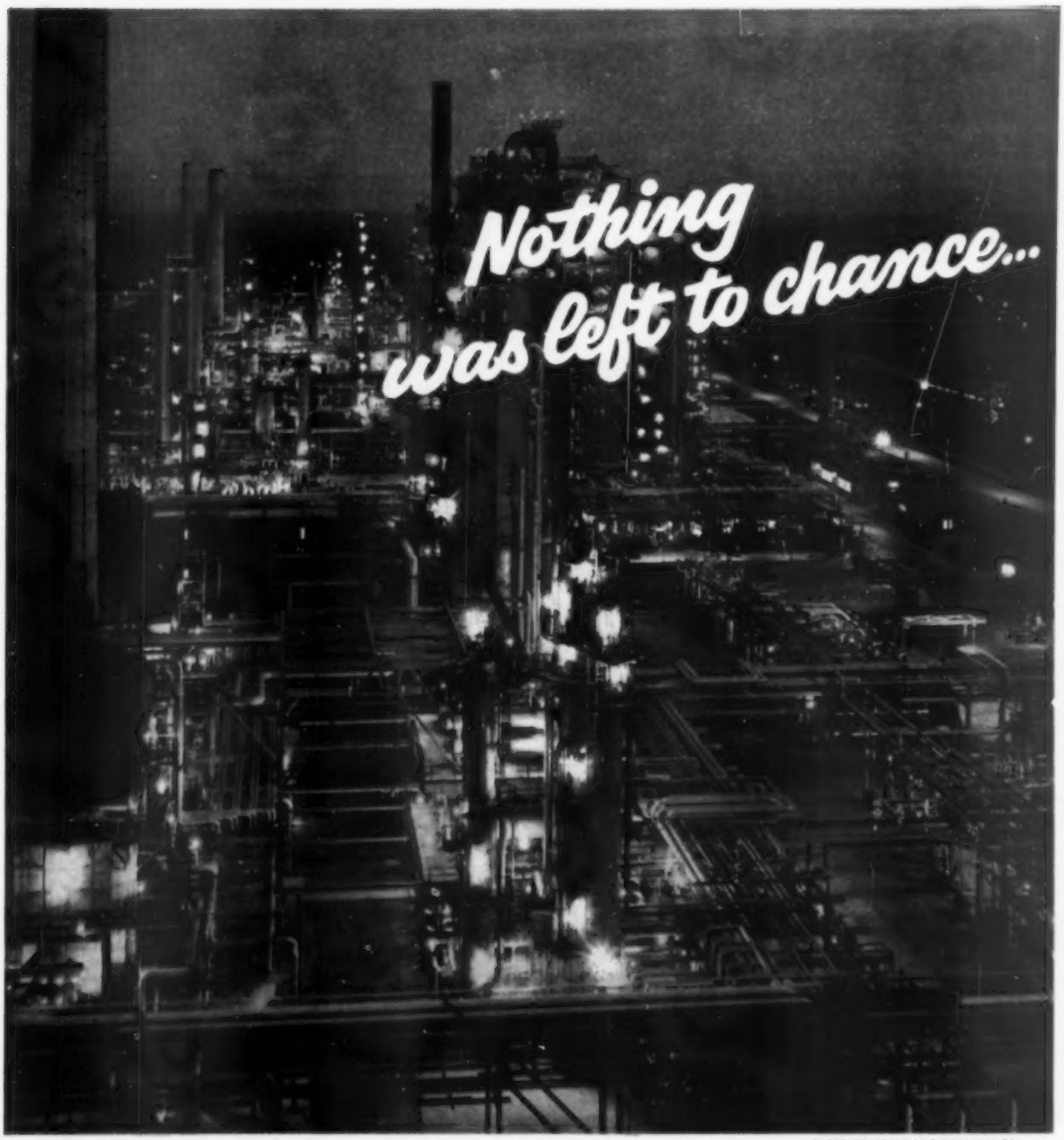
CORROSION costs the petroleum refining industry $270,000,000 a year; a considerable portion of this can be saved by proper painting. In attacking this corrosion problem, first consider what corrodes and why it corrodes — then how to protect it.

Petroleum hydrocarbons themselves are non-corrosive, but production, storage, and refining facilities are attacked by condensate, sour crude, and sweet oil contaminants. Corrosion occurring in the presence of water is called electrochemical corrosion and it is this type rather than the direct chemical reaction of metal with a gas that causes most of the destruction. Elevated temperatures or the presence of both oxygen and water at normal temperatures at a relative humidity in excess of 70 percent cause an increase in the rate of corrosion. Even innocuous stocks can cause corrosion by separation of accompanying water with entrained oxygen.

Any stock or fraction is severely corrosive if operating conditions result in a pH of four or less. This condition can be eliminated by raising the pH to a neutral condition or by stripping the corrosive agent from the stock. Other methods of reducing or preventing corrosion are: The use of corrosion resistant materials such as stainless steel or Monel; the use of cathodic protection; change in environment; change in process procedure; modification in design, and — the most widespread method — the use of coatings. This latter method, which may be metallic, organic, or inorganic, has serious limitations in applicability, temperature resistance and chemical resistance, but it still remains the primary method of preventing corrosion.

Economics

Before undertaking a painting program, a careful analysis should be made to determine if protection is necessary and economical or if an increased corrosion allowance in the original thickness might be adequate. Steel Structures Painting Council data and cost estimating methods indicate the original cost of contract painting oil storage tanks to be about 24 cents per sq ft, including commercial sandblasting. In an industrial atmosphere, the paint life expectancy averages seven years. Repainting should cost 10 cents per sq ft. Twenty year paint life costs less than 44 cents per sq ft. Published cost figures using refining personnel indicate an expected cost of 32 cents per sq ft. By not painting an increas-



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ing thickness of steel plate by a suitable corrosion allowance, the cost will be 40 cents per sq ft when steel costs as little as 25 cents per lb in place. Therefore, it is about as cheap to paint as to add a corrosion allowance. If the cost of capital investment, at five per cent per year, is included, over a 20-year period, then, with steel almost as low as 15 cents per lb, painting is competitive with adding steel.

As the corrosivity of the environment increases, the life expectancy of steel decreases; at the same time, the cost of painting increases because better methods and more resistant materials are required.

Good Painting Practice

Expensive painting systems are not justified economically when used for appearance alone. Such systems should be used in areas of high humidity, in the presence of corrosion accelerating agents and other critical areas.

The most important factors to cover in specifications to assure good service from paint systems are:

1. Proper design to minimize corrosion and to facilitate repainting. Experience proves that failure almost always results from accelerated corrosion of a localized nature — such as along riveted joints or welds or in crevices.

2. Preparation of the surface to a degree consistent with the intended service exposure and requirements of the priming paint to be used. Surface preparation is believed to be the most important of the factors involved in determining the length of the paint life. Pickling or sandblasting lengthens paint life many times over the life on rusted or weathered steel. Weathered surfaces, even though wirebrushed, are extremely poor surfaces to paint; for satisfactory surface, it is necessary to sandblast after weathering. Millscale or slight residues of rust that are intact may be painted over if slow drying primers with good wetting power are used. Care must be taken to leave an anchor pattern conductive to good paint adhesive. This adhesion may be disturbed by a residual film from solvent cleaning, burnishing from excessive wirebrushing, or sharp ridges made by power tools or too large an abrasive.

3. Correct application of paint in a manner that insures maximum paint life yet is commensurate with practical limitations. Generally, adequate film thickness is arrived at by following the directions of the manufacturer. Two methods are available for checking dry-film thickness — by computing the coverage obtained in square feet per gallon (making allowance for losses and volatile) and by utilizing wet-film or dry-film thickness meters. Although five mils are considered much more desirable, sufficient coats should be applied to obtain at least four mils of dried paint for service in normal refinery atmospheres.

4. Selection and use of paints that are properly formulated and can perform the required service. The primer must have the correct pigments for inhibiting corrosion; and the vehicle must have sufficient wetting ability to develop proper adhesion to the type of surface to be painted — this latter factor is critical in deciding paint performance. The second coat of paint should be one which has some degree of rust-inhibiting properties, but it should also have inertness and increased resistance to the passage of water and oxygen. The outer coat of paint must be pigmented so that, if color is important, the color retention is good. It must be inert to the atmosphere in which it will be exposed and must serve to protect the paint system from the effects of ultraviolet light and the weather.

Painting Recommendations

Although the operations of a refinery are complex and the exposures varied, most of the steel can be grouped into one of four categories — storage tanks, process units, yard piping, and buildings.

Storage tanks represent the largest surface area; therefore, a slight decrease in painting cost per square foot per year amounts to significant savings. Painting the roof and shell of volatile-product storage tanks white will substantially reduce breathing losses, but such painting is economical only when the savings from such a reduction outweigh the increased repainting cost in using white paints. Two good white paints for this purposes are SSPC-Paint 104 (type IV) and the white tank paint of the Shell Oil Company. Crude-oil storage tanks should be analyzed on an individual basis to decide the most economical and practical painting method. SSPC Paint Systems No. 1, "Oil-Base Paint Systems (For Weathered Exposed Steel)" and No. 2, "Alkyd Paint Systems (For Weather Exposure, High Humidity, and Infrequent Immersion)" are recommended for the painting of tank exteriors. Complete and detailed specifications for painting are available from the Steel Structures Painting Council.

Process units in mild environments should be painted with the same paint systems as those used for tanks, but finish coats selected should be based on service requirements. For the other extreme, the highly resistant organic coatings or even the use of stainless steel may be necessary. Recommendations are:

Normal Refinery Atmosphere — SSPC Paint System 1 or 2.

High Humidity — SSPC-PS 2 for high humidity and infrequent immersion.

Condensation — An anti-sweat coating (when condensation is due to cold contents). A phenolic, vinyl, or mastic system (when condensation is due to extreme humidity).

Water Immersion—SSPC PS 3, "Phenolic Paint Systems" or PS 4, "Vinyl Paint Systems" specified so that a film thickness of five to six mils is reached. Bituminous coatings may also be used; hot coal tar enamel is best, but three to four coats CA 50 coal tar mastic may be applied (except in potable water).

Chemical — Paint Systems 3, 4, and 9, utilizing Paints 103, 104, and 106, should be selected according to degree of exposure, corrosivity of environment toward the steel, the reactivity between the chemicals and the coating materials, the surface preparation, and the life expectancy required. A table of chemicals and the degree of resistance which may be expected are listed in Chapter 16 of Volume 1 of the Steel Structures Painting Manual.*

Moderate and High Temperatures — The type of paint is dependent on the maximum temperature and the period of duration. Usually up to temperatures of 250-300F alkyd and phenolic paints are satisfactory; special alkyds are obtainable for use up to approximately 500F. Oil paints will protect steel up to 250F. All organic vehicles decompose at 550F and are completely decomposed at 750F.

Insulation — If the surface gets below dew point, steel should be painted even though insulated. The exterior of insulation should be waterproofed. SSPC-Paint 12 is recommended.

Since piping is costly to paint, it is often more economical to replace small piping. Exposed piping should be painted with the same system as for the process units in that area. Hot coal tar enamel, hot asphalt mastic and cement are believed best for underground piping.

The steelwork on the exterior of buildings require the same protection as the remainder of the refinery. Interiors should be painted for good appearance and light reflectivity. SSPC-PS No. 7, a low cost system, should be followed. Decorative topcoats are listed in the complete specifications.

*Steel Structures Painting Manual, Volume 1, "Good Painting Practice" and Volume 2, "Systems and Specifications," Steel Structures Painting Council, Pittsburgh, Pennsylvania, (1954 and 1955).

★ ★ ★

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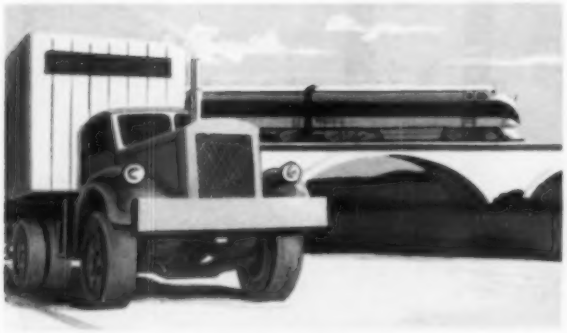

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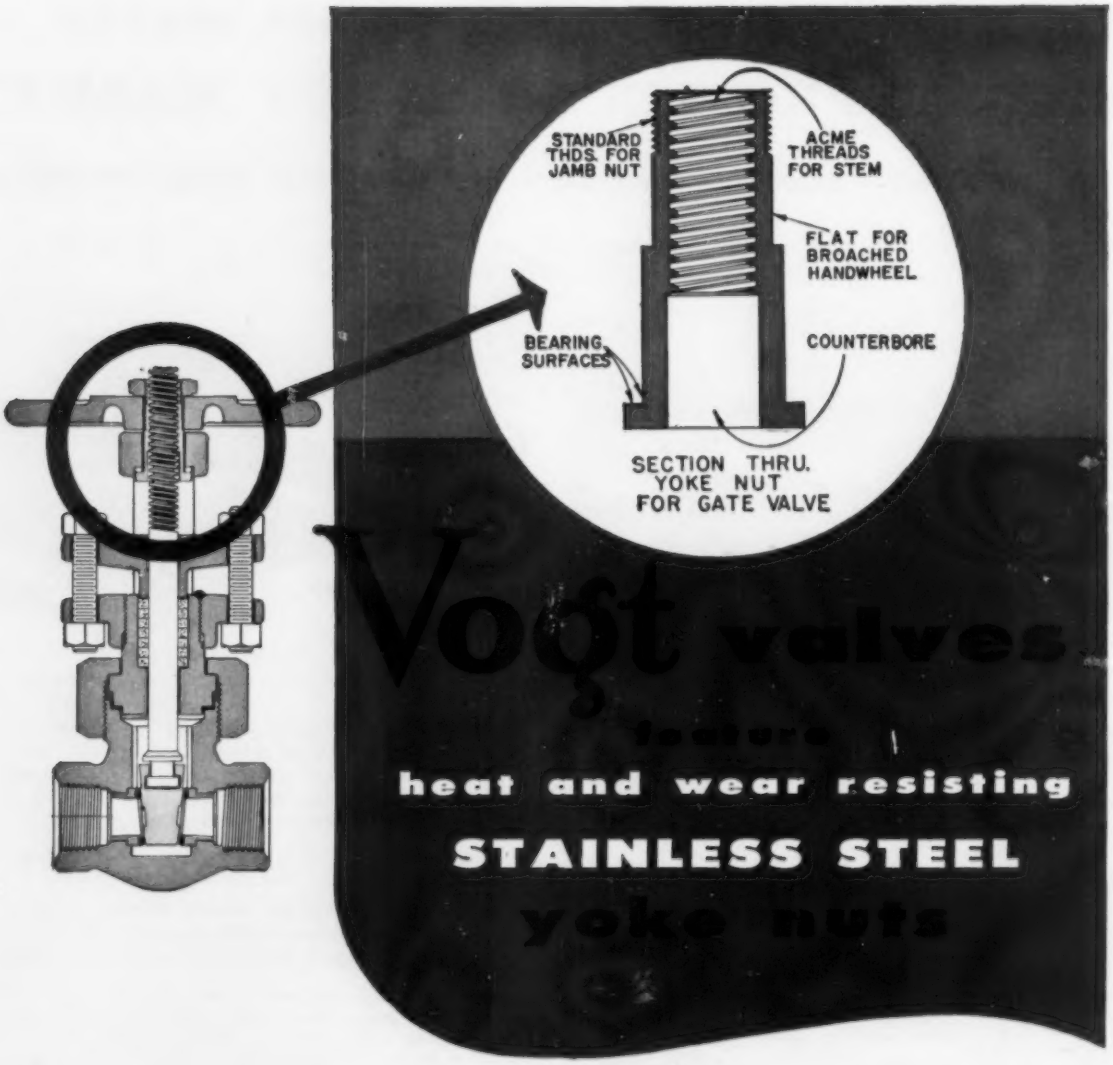

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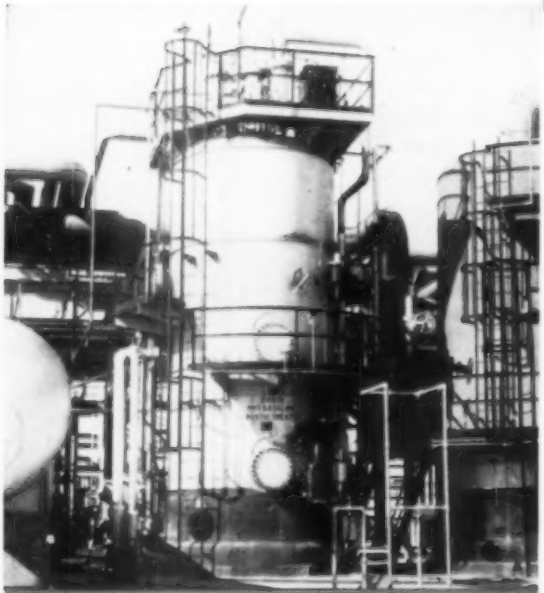

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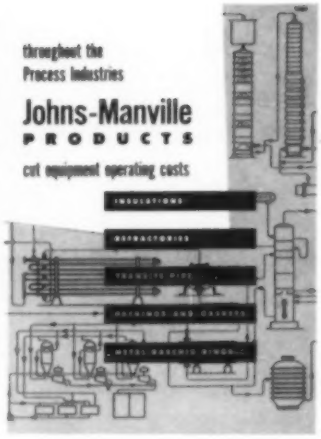

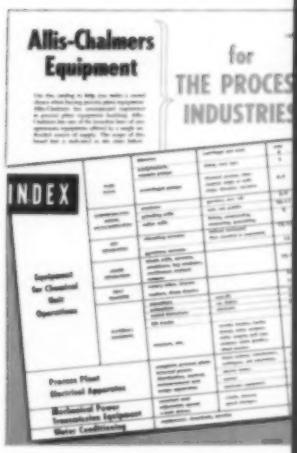

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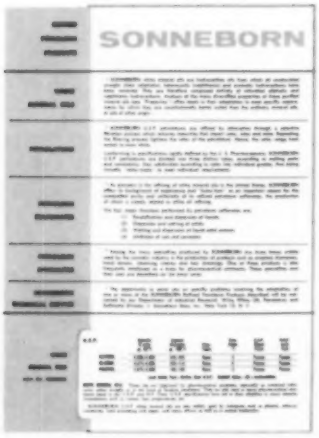

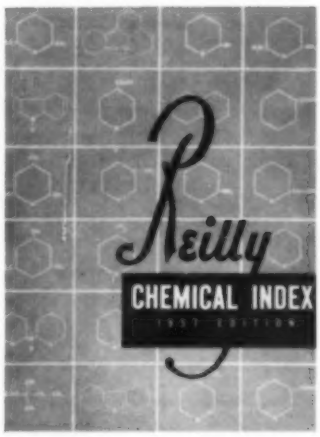

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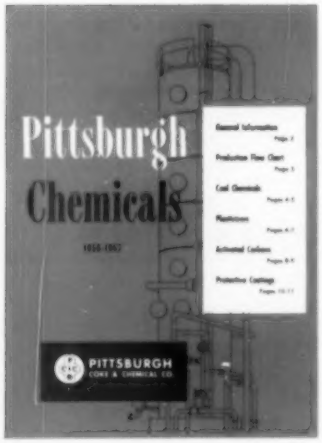

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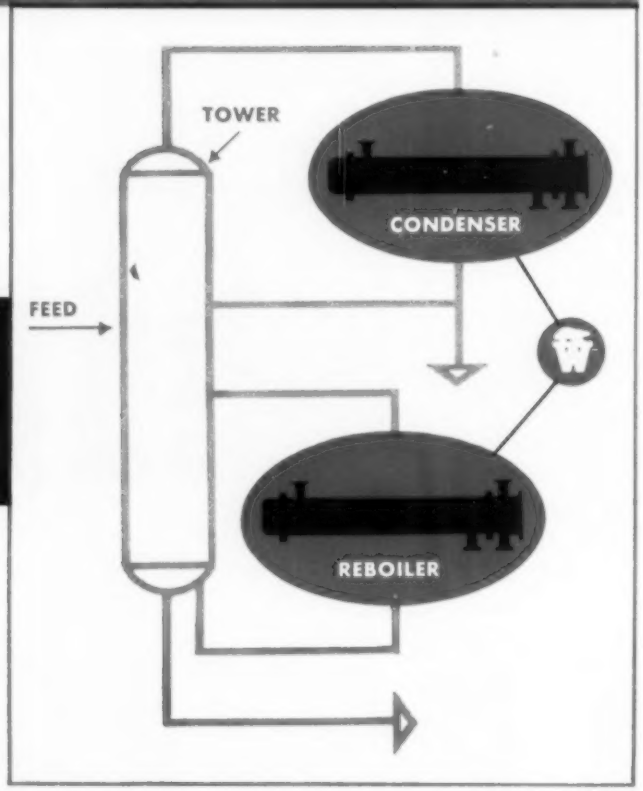

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"Petrobras" was organized in 1953 by the Brazilian government to take charge of that country's oil industry. Here's a timely progress report

P 710.

Brazils' Petroleum Industry

F. Campbell Williams and Antonio Seabra Moggi
Petróleo Brasileiro S/A, Rio de Janeiro

THE future of Brazil's petroleum industry is in the hands of Petróleo Brasileiro S/A, usually known as Petrobras. This company, formed in 1953 by an act of the Brazilian Congress, was given the full responsibility for the development of this industry. On the basis of the first two years of operations the authors believe that Petrobras will develop the industry successfully.

Brazil's petroleum imports have increased on an average of 15 percent per year since 1948 and reached a value of 267 million U. S. dollars in 1956. The percentage of Brazil's total export revenue spent for petroleum imports increased from 10 to 20 percent over this same period. The Brazilian government, a few years ago, decided to make a determined effort to improve this situation. This effort is spearheaded by Petrobras.

Exploration and Production

The large sedimentary basins of Brazil are shown in Fig. 1. Exploration work is being carried out in the most promising areas. Petrobras is training national geologists, drillers, and geophysicists, but this will take a long time. At the moment foreign experts are employed as technical consultants for most of the work.

The only producing area at present is the Bahia Recôncavo Basin near Salvador. During 1956 the production increased from 7000 to 21,000 bbl per day (10 percent of Brazil's needs) and it is expected to reach 40,000 bbl per day in 1957. A non-commercial producing well at Nova Olinda, near Manaus, has increased the hopes for oil in the Amazon Basin.

Refining

Petrobras will expand the capacity of Brazilian refineries to 330,000 bbl per standard day by 1960 — the estimated internal demands at that time. Eight refineries, two of which are owned by Petrobras, are now refining 125,000 of the 200,000 bbl per day required.

Brazil's first complete refinery, Refinaria Ipiranga in Rio Grande do Sul, processes 6000 bbl per standard day of Oficina crude with a crude unit and thermal cracking. The crude from the Bahian fields is refined in Petrobras' Mataripe refinery. It is a 6000 bbl per standard day combination unit with catalytic polymerization. This plant, scheduled to be revamped and expanded to 37,000 bbl per standard day, will include a fluid catalytic cracker, one of the world's largest wax plants, rated at 60 tons a day, and the nation's first lube oil plant, having a capacity of 3000 bbl per standard day.

In Rio de Janeiro, the Refinaria de Petroleos de Manguinhos S/A processes 10,000 bbl per standard day of Oficina crude, includes a combination unit and catalytic polymerization. In São Paulo, Refinaria e Exploracão de Petroleo "União" S/A (Capuava) was designed for 20,000 bbl per standard day but with modifications now refines 30,000 bbl per standard day of Kuwait crude with a crude unit, Thermofor catalytic cracking, and catalytic polymerization. Near Santos, Petrobras' Refinaria Presidente Bernardes (Cubatão), designed for 45,000 bbl per standard day, is now processing 65,000 bbl per standard day of Arabian, Bahian, or Venezuelan Recon crudes. It has a crude unit, thermal cracking and reforming, catalytic polymerization, and gas recovery. The SO_2 Edeleanu treating plant, originally designed for kerosine, is now used to make an aromatic naphtha extract to improve gasoline. Cubatão is the only refinery in Brazil producing premium motor

*Condensed by the authors from a paper presented to the AIChE Annual Meeting, Boston, Massachusetts, December, 1956.

gasoline. In addition, an asphalt plant at the Cubatão site processes Boscan crude.

Refinery Expansions

Bids are now being called for a 90,000 bbl per standard day refinery in Rio de Janeiro. This will have a crude unit, catalytic cracking and catalytic reforming. It is hoped that this refinery and the Mataripe expansion will be on-stream in 1959. Three new refineries, each of 30,000 bbl per standard day, are being studied for Rio Grande do Sul, the state of São Paulo, and northern Brazil, respectively.

Petrochemical Industry

The law establishing Petrobras does not grant the company a monopoly in the petrochemical industry, and the policies of the present Brazilian government indicate that no monopoly is presently contemplated. However, Petrobras has already begun to manufacture starting materials and products vital to the growth of the country. Petrobras has built a 100 ton per day ammonia plant to process Cubatão refinery gas. The fertilizer plant will produce 340 tons per day of fertilizer early in 1957.

An ethylene recovery plant for Cubatão is now being built by Petrobras. The present supply of refinery gas limits it to 20 tons per day of ethylene, but this will be increased to 60 tons per day with ethane pyrolysis. The ethylene will be sold to private companies being constructed around the refinery. Five tons daily will go to Kopper's styrene plant; 10-14 tons daily will go to Union Carbide's polyethylene plant; and a small amount will be chlorinated by Electrochloro S/A to make insecticides.

Petrobras is planning a propane-propylene splitter at Cubatão. The propane will be sold as LPG and the propylene will be sold to Rhodia do Brasil for isopropyl alcohol and ketones.

Two companies will process liquid residuum products from the Cubatão refinery to produce 20,000 tons per year of carbon black.

There have been several requests for benzene at the Cubatão refinery. However, Petrobras has decided not to modify Cubatão but to wait until the new catalytic refinery is built in Rio de Janeiro. Also, in conjunction with the new Rio refinery, a rubber plant is being studied to produce 40,000 tons per year of synthetic rubber to make up the deficiencies in the natural rubber supply from the Amazon.

Shale Oil

A modern and flexible shale oil pilot plant has been built at Tremembe, São Paulo State, at the site of the Paraiba shale deposits. The plant has already successfully completed studies on the wet Paraiba valley shales and work is now beginning on the shales from the large deposits in the Irati Valley. In the light of the economic factors in a country with soft currency, this shale project appears quite interesting.

Petroleum Refining School

With the rapid refinery expansion, Brazil needs trained and competent refinery engineers. A special graduate school was formed about five years ago to supply these engineers. They are carefully selected from graduates of Brazilian universities and trained for a full year by foreign and Brazilian professors.

The courses cover all phases of unit operations of interest to a refinery, petroleum refinery design, refinery equipment and operations, instrumentation and process control, thermodynamics, process design for the modification of Brazil's refineries, routine analysis and crude evaluation, as well as technical writing, leadership, conference procedure, and personnel problems. The training center is well equipped with modern laboratories for the practical training. Part of the year is spent by the students in the refineries working on shift as operators. After the course they are given jobs in the refineries to gain further operating experience.

Geology School

In June 1957, an 18-month graduate course in geology will begin in Bahia. Foreign professors will be brought to Bahia to organize the school and the courses.

What's Ahead

The future plans of Petrobras are:

1. Increased exploration and crude production,
2. Expansion of Brazil's refinery capacity in 1960 to 330,000 bbl per standard day — 100 percent of internal needs,
3. Expansion of tanker fleet from 200,000 tons to 400,000 tons by 1960,
4. Creation of a complete research and training center — perhaps a Brazilian Petroleum Institute, and
5. Increase capital assets to 35,000,000,000 cruzeiros ($1.8 billion at the official exchange) by 1960.

From the results of the achievements of the first years the authors have confidence in the future of Petróleo Brasileiro S/A. ★ ★ ★

REFINING IN BRIEF

P 801.

Differences in Road and Laboratory Octane Numbers

Four Motor Octane Number units may be saved at 65 mph, with only one percent power loss

E. S. Corner

Esso Research and Engineering Company

THE petroleum and automotive industries have the common objective of maintaining a balance between gasoline antiknock quality and car octane requirements. To accomplish this objective, a technique is required that will accurately predict the road antiknock quality of gasolines from relatively simple laboratory tests. Engines in cars on the road operate over a wide range of severity conditions. Moreover, variations exist from car to car in engine and transmission design. The antiknock quality of a fuel must be measured in test engines differing in severity in order to predict the ability of a fuel to give satisfactory antiknock performance under the variety of severity conditions to which it will be subjected in the field. The Research and Motor Method octane ratings fulfill these conditions.

The paper discusses the derivation and application of an equation that gives good correlations between Road

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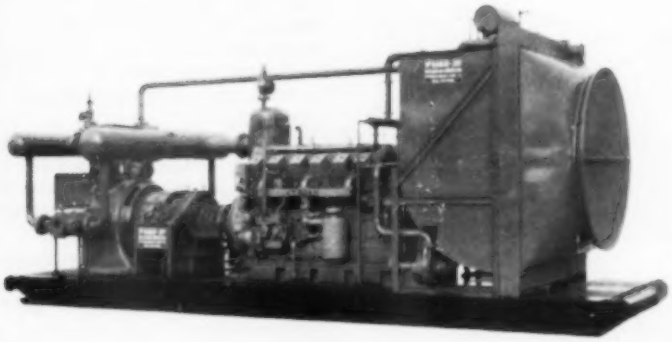

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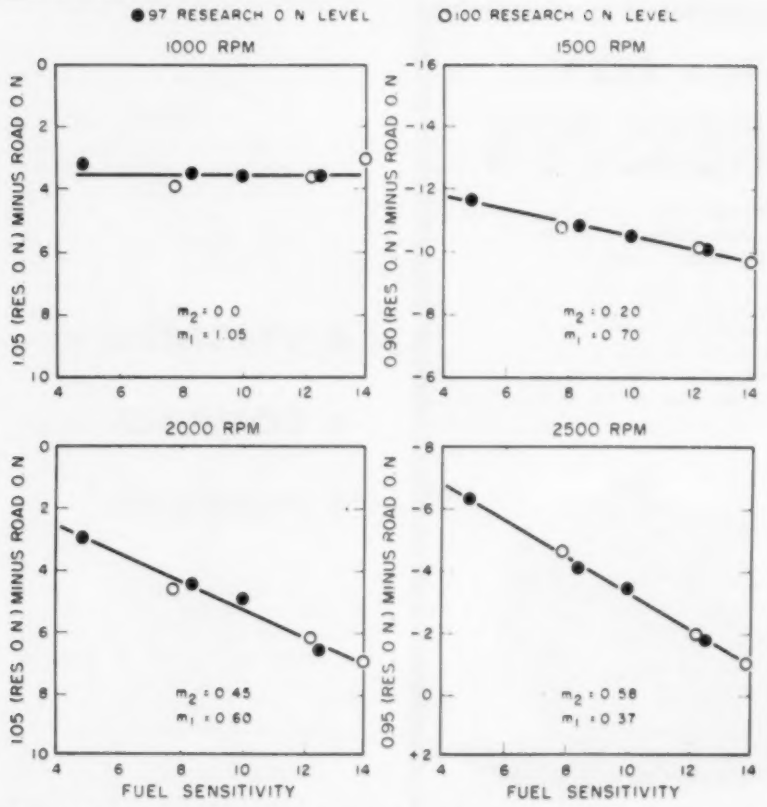
●97 RESEARCH O N LEVEL
○100 RESEARCH O N LEVEL
1000 RPM
1500 RPM
2000 RPM
2500 RPM
1 05 (RES O N) MINUS ROAD O N
0 90 (RES O N) MINUS ROAD O N
0 95 (RES O N) MINUS ROAD O N
m2 = 0 0
m1 = 1.05
m2 = 0 20
m1 = 0 70
m2 = 0 45
m1 = 0 60
m2 = 0 58
m1 = 0 37
FUEL SENSITIVITY
FUEL SENSITIVITY

Effect of fuel sensitivity on borderline road octane number in 10:1 compression ratio engines, with automatic transmissions.

octane numbers of conventional volatility gasolines, made up from refinery streams, and their laboratory octane numbers. This equation takes the form of

Road O.N. = m_1 (Research O.N.) + m_2 (Motor O.N.) + C . . . (1)

where m_1 is the increase in Road O.N. per unit increase in Research O. N. and m_2 is the increase in Road O. N. per unit increase in Motor O. N. The coefficients m_1 and m_2 are constant at any given speed of knock in any one car. Individual values of m_1 and m_2 vary from about —0.4 to 2.0 or more. The constant C, which may be positive or negative, is a correction factor to obtain numerical agreement between actual and calculated Road O. N. Techniques for determining m_1, m_2, and C are discussed. In limited cases, other fuel parameters can be important as well.

To illustrate the influence of Motor O.N. (m_2) on Road octane ratings, it is convenient to use an alternate expression involving fuel sensitivity. Substituting Motor O. N. = Research O.N. — Sensitivity into (1) it becomes

Road O. N. = (m_1 + m_2) Research O.N. —m_2 Sensitivity + C (2)

or (m_1 + m_2) Research O.N. — Road O.N. = m_2 Sensitivity — C . . . . . (3)

The slope of the line obtained when plotting the expression on the left of Equation (3) (as ordinate) against sensitivity is m_2, the effect of Motor O.N. In the special case where m_1 + m_2 = 1.0, Equation (3) becomes equivalent to the usual method described in the literature for evaluating the influence of Motor O.N. on road octane ratings, namely, as the slope of the line obtained by plotting road depreciation (Research O.N. — Road O.N.) against sensitivity. Since m_1 + m_2 seldom equals unity, the method outlined in this paper gives improved correlations in most instances. Variations from about 0.6 to 1.5 have been encountered. The significance of this sum (m_1 + m_2) is that it measures the increase in Road O.N. per unit increase in Research O.N. for fuels of a constant sensitivity.

Studies in both older (6.8-7.0:1 C.R.) and experimental 10:1 C.R. cars show that the variable having the greatest influence on the relative importance of Research and Motor O.N. on Road O.N. is the speed at which knock occurs. Compression ratio has only a small effect. The importance of Motor O.N. increases in a regular manner with increasing engine speed and that of Research O.N. decreases. These trends are shown in Fig. 1 by means of correlations of Borderline data obtained in a group of eight 1954-55 cars equipped with experimental 10:1 C.R. engines. If knock is critical at 1000 rpm, Motor O.N. or fuel sensitivity has no effect, and road antiknock performance is controlled by Research O.N. This is usually the case with cars having manual shift transmission. If knocking occurs at 2000 or 2500 engine rpm, however, the influence of Motor O.N. approaches or exceeds that of Research O.N.

The trend during the past several years has been in the direction of higher engine speeds of knock, and hence an increasing importance of Motor O.N. Several factors are contributing to this trend:

1. Fuels tend to increase in sensitivity with increasing Research O.N. Gasolines of high sensitivity are more likely to knock at high engine speeds than fuels of low sensitivity.

2. The automatic transmission, especially the torque converter type, has shifted the minimum speed of knock to higher engine speeds of 1500 to 2000 or more. The importance of Motor O.N. in torque converter transmission equipped cars is shown in the following table. Estimated effects at 10:1 C.R. are based on assumptions of knock at 2000 to 2500 rpm. The trend is in this direction.

Uniontown Ratings in Torque Converter Equipped Cars at Low Car Speeds.

	1948-51	1955	10:1 C. R.	
Model Year				
Speed of Knock, rpm	1500—1650	Not Determined	2000	2500
Effect of				
Research O. N. (m_1)	0 63	0 36	0 60	0 37
Motor O. N. (m_2)	0 45	0 72	0 45	0 58

The high compression ratio data, assuming knock at 2000 rpm, are in remarkably close agreement with the 1948-51 cars. In the 1955 cars, the effect of Motor O.N. was twice that of Research O.N. If future 10:1 C.R. cars with torque converters knock at 2500 rpm, Motor O.N. will be more important than Research O.N. in these cars as well.

3. Finally, engine breathing at high speeds has been improved, the four-barrel carburetor being a factor. Charge density is increased, thus raising octane requirements relative to requirements at low speeds. In older cars, which had been raised to high compression ratios, it was indicated road octane depreciation due to high speed knock would not take place on 100 Research O.N. fuels having Motor octane num-

Condensed by the author from the paper, "Octanes — From Laboratory to Road," presented before the Society of Automotive Engineers, June 6, 1956.

November, 1912 NATIONAL PETROLEUM NEWS 33

STEEL TANKS and PLATE WORK

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NEED NO INTRODUCTION TO THE
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AS THEY HAVE BEEN
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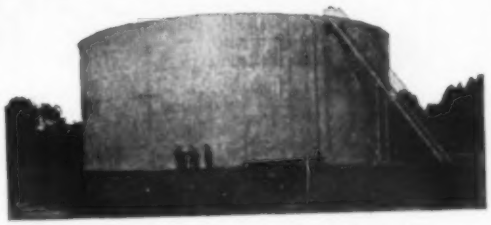
EVER SINCE THE DISCOVERY OF OIL



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In addition to their corrosion inhibiting properties, these same Kontol Products are protecting the equipment against fouling, because of their powerful detergent effect.

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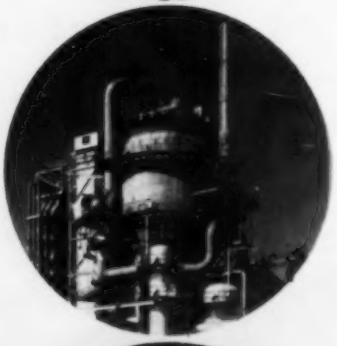

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THE MAN IN THE TRETOLITE CAR

Photo Courtesy C. F. BRAUN & CO. Engineers and Constructors Alhambra, California

TT-57-1

bers of 87 or 88. In the recent studies, however, avoidance of high speed knock would require a fuel of higher Motor O.N. than the petroleum industry can economically supply in volume. The large reductions in Road O.N. due to high speed knock where accelerations are carried out to 65 and 80 mph are shown in the following table. It is assumed that low speed knock would be critical at 1000 rpm.

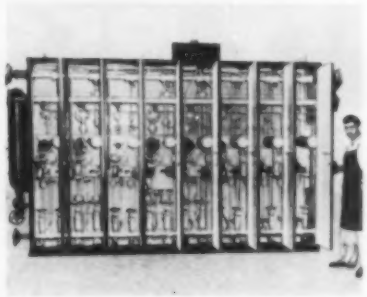
Influence of High Speed Knock on Road Antiknock Performance.
10:1 C. R. Cars; Hydra-Matic Transmission; 100 Research O. N. Fuel.

	Road Octane Number		
Car Speed of Knock: Motor O. N.	Low	65 mph	80 mph
92	101.5	100.7	98.4
90	101.5	99.7	97.5
88	101.5	98.8	96.7

Based on these data, spark retard at high engine speeds will be required to match future fuels and engines. In this connection, limited data show that the Motor O.N. requirement at 65 miles per hour can be reduced four units for only a 1 per cent loss in power. The cost to the petroleum industry and hence to the motoring public of four Motor O.N. units for only one per cent more power will be very great. It is therefore important that the car manufacturers do everything possible in the design of their engines to reduce their Motor O.N. requirement.

In summary, equations have been developed that give good correlations between the Road octane numbers of conventionally made gasolines and their Research and Motor octane numbers. The petroleum industry will have to consider the influence on both Research and Motor O.N. of new refinery processing for motor gasoline production. If other fuel parameters also become important with future type commercial fuels and cars, additional terms can be added, as required, to the type of equation developed for Research and Motor O.N. effects only. ★ ★ ★

Hydraulic Valves Control Dehydrogenation Reactors



Complete, encased hydraulic control unit for operating seven gate valves of one butadiene reactor vessel. Eighth panel operates reactor by-pass valve in case of emergency.

A hydraulic control valve system, one of the largest of its kind, is used to regulate each of the seven butane dehydrogenation reactors at Texas Butadiene and Chemical Company's new plant near Houston, Texas. Each of the reactors operates on a 20-minute cycle — reaction, during which time coke is deposited on the chrome oxide-alumina catalyst, purge and evacuation, regeneration with air, purge and evacuation, followed again by a reaction period. At any given time there are three reactors onstream, three on regeneration, and one on purge, evacuation, or valve change.

Each of the reactors has seven gate valves controlling the flow of feed, products, vacuum purge, combustion air, flue gas, etc. There are a total of 98 hydraulically controlled valves comprising the entire system.

Automatically controlled by a cycle timer, the power requirements — at a central power unit — are only 30 hp. An electrical control system would have required 400-500 connected horsepower for valves ranging from 4 to 30 in. diameter. The valves are operated by small hydraulic cylinders which in turn are operated by solenoid valves at the central control panels (see photograph). Operating times for the gate valves are as low as one second for the smaller units to four seconds for the larger valves.

Four-way solenoid valves control the flow of hydraulic fluid to the control valves. Power requirements are minimized by the use of ten 10-gallon hydro-pneumatic accumulators that discharge about 20 gal of oil every three minutes, the peak circuit demand.

Several advantages are cited for the system. Control wiring and size of the installation were reduced to about one-tenth of that of an electrical system. Also, rate of valve travel can be varied at any point in the stroke, and slow stops and starts that eliminate "slamming" are gained by simple external valving. And, the actual operating forces required to move the valve gate can be varied by simply adjusting the relief valve.

System was designed and built by Rivett, Inc., of Boston, Massachusetts.

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Heat and vibration-proof, non-solvent, will not shrink, crack or crumble. Makes all assemblies leak-proof and pressure-tight. Prevents rust, corrosion, joint seizure.

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LOOSENS rusted bolts, nuts, screws, 'frozen' parts

Liquid Wrench works *fast*... yet is absolutely safe for all metals and alloys.

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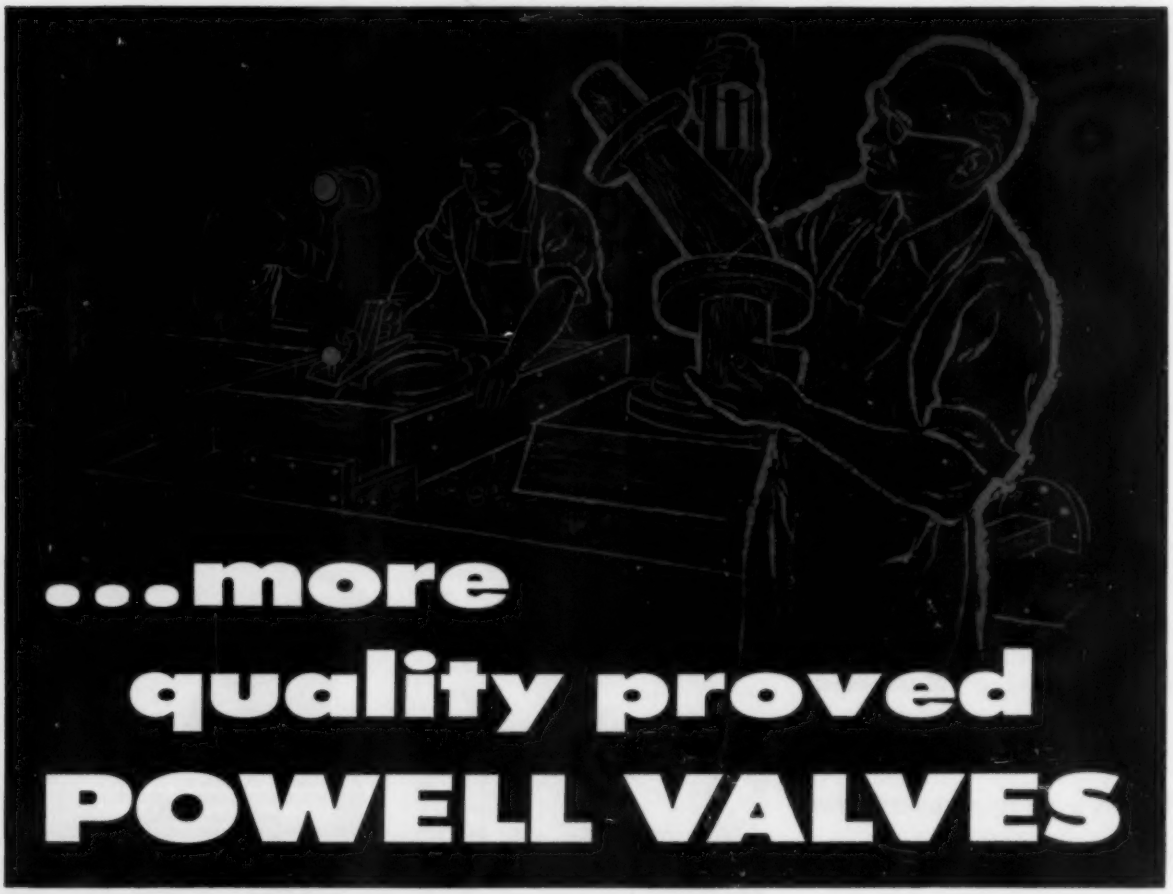

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Fig. 2201—175-Pound W.O.G. Semi-Steel Lubricated Plug Valve.

Fig. 86196—Steel "LPG" Horizontal Lift Check Valve for 400 W.O.G.

Fig. 375—Bronze Gate Valve for 200 Pounds W.S.P. Union Bonnet. Inside Screw Rising Stem.

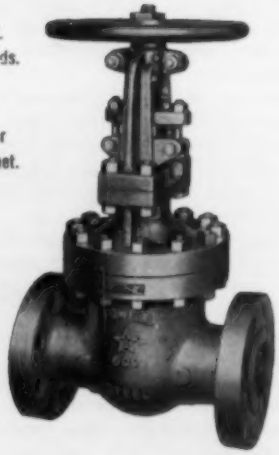

Fig. 6003—Steel O.S.&Y. Gate Valve for 600 Pounds.

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If you are a pipeliner

you'll appreciate this self-sealing gasket in UNIBOLT scraper trap and blowdown closures

Little things . . . like the gasket for a scraper trap or blowdown closure for example . . . can be a big headache. But not this one. It is the self-sealing gasket used in UNIBOLT pipeline couplings. The UNIBOLT design makes line pressure do the sealing. And this design practically encloses the gasket in steel so that when the closure is opened and closed the gasket is hardly disturbed. Made of oil- and gas-resistant Hycar nitrile rubber, this gasket will last indefinitely under normal conditions.

UNIBOLT scraper trap and blowdown closures are hinged for easy operation. Release only two bolts and the closure swings open and shut like a door. No heavy lifting. No time-consuming multi-bolt flanges. Write for complete information.

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Roundup of Planned and Proposed Construction

The following tables list the company, mileage, pipe size, and location of proposed pipeline projects — crude, products, and natural gas — reported to *The Pipeline Engineer*. Company addresses are given when known.

CRUDE LINES

Name of Company	Miles	Size	Location
Act Oils, Toronto, Ontario	350	—	Line from Peace River area in British Columbia, thru Pine Pass to Prince George, westward to Bella Coola terminus on Pacific Coast
Atlantic-Cities-Service-Continental-Gulf-Phillips-Texas-Sinclair	Approx 385	26	Midland, Texas, area to Houston
Cape Pipe Line Company Philadelphia, Pennsylvania	200	—	Large diameter from Delaware Bay to Greater Philadelphia area refineries
Lakehead Pipe Line Company, Inc. Toronto 1, Ontario, Canada	80	26	Loop from Clearbrook, Minnesota, to Superior, Wisconsin
Oil Field Pipe Line, Inc. Wichita, Kansas	—	8	To extend northeast from Hugoton field, Kansas, to Raymond, Kansas tie-in with Arapahoe Pipe Line system
Muskegon Pipe Line Corporation Muskegon, Michigan	165	10	Griffith, Indiana to Muskegon, Michigan to supply Aurora and Naph-Sol refineries
North-West Oil Pipelines Company	210	—	Wilhelmshaven, on the North Sea, to industrial Ruhr area of West Germany
Northwest Pipe Line Corporation Salt Lake City, Utah	350	8–10	Four Corners area to Salt Lake City, Utah
Offshore Gathering Company Houston, Texas	364	20	Gulf of Mexico from Sabine Pass to Mississippi River
Royal Dutch Shell Group and Others The Hague, Netherlands	870	30	Marseille, France, to Rotterdam, Holland, and Antwerp, Belgium
Royal Pipe Lines, Ltd. Regina, Saskatchewan, Canada	288	Var.	Cantuar area fields to Glenavon
Salt Lake Pipe Line Company Salt Lake City, Utah	100	10	Additions to Rangely, Colorado-Salt Lake City line
Seventeen American, British, French and Dutch companies	—	38–40	Likely route to run from head of Persian Gulf, through Iraq and Turkey to Turkish coast on the Mediterranean Sea
Sinclair Pipe Line Company Independence, Kansas	150	20	Teague to Houston, Texas
Southern Kansas Pipe Line Company	310	6, 10	10,000 bbl per day line from Greenwood pool, near Colorado line, thru Liberal to Arkansas City, Kansas
Texas-New Mexico Pipe Line Company Houston, Texas	515	16	Extension from Jal, New Mexico, pump station to Four Corners area
Trans-Border Pipe Line Company	110	—	Skagway, Alaska, to Whitehorse, Yukon Territory

PRODUCTS LINES

Name of Company	Miles	Size	Location
Equitable Gas Company and Subsidiaries Pittsburgh, Pennsylvania	100	4–5	Maytown, Kentucky, to Institute, West Virginia
Great Lakes Pipe Line Company Kansas City, Missouri	84	8	Eau Claire, Wisconsin, laterally from a point on existing lines south of St. Paul, Minnesota
	68	12	To Chicago from juncture of Great Lakes' lines with Badger system. Will supplant existing 6-in. line
	140	8	Connect terminals between Minneapolis and Superior, Minnesota
	34	12	Tulsa to Barnsdall, Oklahoma, loop
	14	8	Coffeyville to Independence, Kansas
	11	8	Line between point near Donahue, Iowa, pump station to Mississippi River terminal at Bettendorf, Iowa
Laurel Pipe Line Company Pittsburgh, Pennsylvania	440	14–24	Philadelphia to Pittsburgh to Cleveland
Northwest Pipeline Corporation Salt Lake City, Utah	350	8–10	Four Corners to Salt Lake City, Utah
Ohio Oil Company	—	—	Common carrier line from Wood River, Illinois, to Chicago
Findlay, Ohio	—	—	Connecting line from Robinson, Illinois, refinery to new line
Salt Lake Pipe Line Company Salt Lake City, Utah	80	8	Additions to Boise, Idaho, to Pasco, Washington, line
Service-Continental-Sinclair-Phillips	550	—	Salt Lake City, Utah, to Spokane, Washington
Texas Eastern Transmission Corporation Shreveport, Louisiana	1168	16–20	Conversion of "Little Inch" between Beaumont, Texas, and Moundsville, West Virginia
Union Oil Company of California	815	—	Shale Oil Plant, Rifle, Colorado, to Los Angeles area
Winnipeg & Central Gas Company Winnipeg, Manitoba, Canada	210	6	U. S.-Canadian border to Winnipeg

HD-21 *(Illustrated)*

Hydraulic torque converter drive
204 net engine hp
Weight—78,250-lb tractor and side boom with full counterweight
127,000-lb lifting capacity at 4-ft overhang

HD-16

Hydraulic torque converter drive (optional)
150 net engine hp
Weight—57,840-lb tractor and side boom with full counterweight
77,580-lb lifting capacity at 4-ft overhang

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

It's easy to handle the pipe when it's easy to control the machine

CRADLING or lowering in pipe on steep hillsides or in mucky swamplands demands a crawler operator's full attention. That's why operators appreciate the many easy-operating features of an Allis-Chalmers crawler tractor and Tractomotive side boom. They provide precise maneuvering with a minimum of effort.

Finger-tip hydraulic booster steering

on the HD-16 and HD-21 requires only 3- to 5-lb pressure on the controls. Self-energizing brakes make brake-clutch coordination especially easy. They require less pedal pressure and take hold with a firm, uniform grip.

Easy-working side boom levers

Counterweights extend or retract smoothly in response to finger-tip pressure, enabling operator to maintain precise balance even on rough terrain. Side boom levers are within easy reach of operator and spaced to give ample hand room.

Matches speed automatically

The operator merely advances or retards throttle to synchronize tractor speed to that of cleaning-priming or doping-wrapping machines. There's no need to shift or slip the clutch with Allis-Chalmers hydraulic torque converter drive. Operator's hands are free for side boom work. Hydraulic torque converter drive, pioneered and proved in crawler tractors by Allis-Chalmers, is standard on the HD-21 and optional on the HD-16.

Greater operator comfort

Add to these advantages roomy, adjustable cushion seats, wide arm rests, electric starting, and it's easy to see why an operator does more with less effort when he's behind the controls of an Allis-Chalmers-Tractomotive combination. Let your dealer prove it with a demonstration.

TRACTOMOTIVE CORPORATION, DEERFIELD, ILLINOIS

TRACTOMOTIVE

ALLIS-CHALMERS, CONSTRUCTION MACHINERY DIVISION
MILWAUKEE 1, WISCONSIN

ALLIS-CHALMERS

GAS LINES

Name of Company	Miles	Size	Location
Arkansas Louisiana Gas Company	300	—	Main and gathering lines Louisiana-Texas Gulf Coast
Andes Pipeline Corporation	500	12	Villamontes, Bolivia, to Antofagasta, Chile
Cities Service Oil Company	70	—	Gas gathering system on the Roberts Ranch, Midland, Texas
Bartlesville, Oklahoma	115.6	Var.	Montgomery, Allen, Anderson, Franklin, Miami, Johnson, Wilson counties, Kansas
Coastal Transmission Corporation	574	22–26	McAllen, Texas, to Baton Rouge, Louisiana
Dallas, Texas	414	Var.	Gathering lines in Rio Grande Valley, Texas
Colorado Interstate Gas Company	345	30	Kit Carson, Colorado, to Beatrice, Nebraska
Colorado Springs, Colorado	100	24	Springfield to Pueblo, Colorado
	24	24	Greenwood to Panhandle-Kit Carson loop
	109	26	Loop from Fourway, Texas, to Springfield, Colorado
	66	30	Loop from Springfield to Kit Carson, Colorado
	10	16	Keyes field, Oklahoma, to mainline
	6	10	Tablerock field, Wyoming, to mainline
	12.0	12–24	Additions in Texas Panhandle fields
	50	22	Mocane field, to Hooker, Oklahoma
Eastern Shore Natural Gas Company	124	6, 8	Transmission line and facilities in Delaware and Maryland
Salisbury, Maryland			
Kansas-Nebraska Natural Gas Company	61.3	Var.	Gathering lines from Camerick field to Liberal, Kansas
Phillipsburg, Kansas	10	10	Grand Island to Fullerton, Nebraska
	10	8	Loop from Grand Island to Fullerton, Nebraska
	11.5	12	Replacement from Scott City to Oakley, Kansas
	1.2	6	Additions to system in Nebraska
	9	8	Lexington to Central Nebraska Public Power Electric Plant
	14	16	Replacement from North Platte to Maxwell, Nebraska
Midwestern Gas Transmission Company	1112	12–24	Mainline from U. S. Canadian border near Emerson, Manitoba — Noyes, Minnesota, to Portland, Tennessee
	648	3–18	Laterals of mainline to serve communities in Minnesota, North Dakota, and Wisconsin
Natural Gas Pipe Line Company of America	38	36	Joliet to Elgin, Illinois
Chicago, Illinois	405	36	Beaver County, Oklahoma, to Joliet, Illinois (loops)
	25	—	Gathering line from Quinduna field, Roberts County, Texas, to point on existing line
	91	30	Loops in Nebraska, Kansas, Oklahoma
	337	30	Looping between Texas terminus and Beatrice, Nebraska
Northern Natural Gas Company	28	24	Ogden to Redfield storage area, Iowa
Omaha, Nebraska	168	20	St. Paul-Minnesota to Duluth, Minnesota, and Superior, Wisconsin
	100	20–24	Savannah Creek field, Alberta, to Alberta-Montana border near Cardston, Alberta
Northern Plains Natural Gas Company (subsidiary of Northern Natural Gas Company)	1100	26	Alberta-Montana border to Minneapolis, Minnesota
Omaha, Nebraska			
Offshore Gathering Company	364	30	Offshore gas line in Gulf of Mexico from Sabine Pass to Mississippi River
Houston, Texas			
Pacific Gas & Electric Company	200	12	Glenn and Tehama counties to Eureka and Arcata, California
San Francisco, California			
Pacific Lighting Gas Supply Company	80	30	Coles Levee to Newhall, California
Los Angeles, California	2.1	16–20	Potrero to Newhall, California
	2.8	16	Lines in East Whittier, California
Tennessee Gas Transmission Company	264	26, 30	Loops in Tennessee, Kentucky, West Virginia and Pennsylvania
Houston, Texas	557	30	From existing facilities in Mississippi Delta south of New Orleans to Portland, Tennessee
	76	24	Coudersport, Pennsylvania, to Hamburg, New York
Texas Eastern Transmission Corporation	690	30	Loop lines between Kosciusko, Mississippi and Uniontown, Penn.
Shreveport, Louisiana	105	30	Loop lines between Vidor station (Texas) and Kosciusko, Mississippi
	22	14	Lateral supply lines
Texas-Illinois Natural Gas Pipeline Company	59	20	Joliet to Volo, Illinois
Chicago, Illinois			
Trans-Canada Pipe Lines, Ltd.	2294	20–34	Winnipeg to Montreal and laterals
Calgary, Alberta, Canada			
Transcontinental Gas Pipe Line Corporation	13	24	Purchase lateral in Louisiana
Houston, Texas	28.5	16	Purchase lateral in Gulf of Mexico, off Louisiana Coast (7.5 mi. offshore)
	213	12–24	Purchase laterals in Texas
	42	36	Additional mainline looping
	16	30	Additional mainline looping
Westcoast Transmission Company, Ltd.	174	30	Line from Savannah Creek gas field, Alberta, to existing system

EXTRA MILES...

WITH

PEAK MOBILE RADIO POWER

☆ 100 WATT POWER OUTPUT ☆ MAXIMUM RANGE

☆ EXTENDED COVERAGE ☆ TOP RECEIVER SENSITIVITY

Motorola "TWIN-V" radiophone—with highest power, to push the range of your VHF radio system to its maximum—to optimize mobile-to-base and mobile-to-mobile communications in the farthest fringe areas.

Here peak receiver sensitivity combines with highest transmitter output to assure dependable reception of all communications. Advanced design provides full 100 watt rated output. Yet the economical battery drain is comparable to conventional 60 watt equipment—plus full 6/12 volt interchangeable operation, without changes or modifications, for obsolescence protection in mixed fleets.

The 25-54 mc. 100 watt mobile radio equipment includes all the forward-looking engineering of the "TWIN-V" radiophone line:

- **Conservative long-life design**
- **Reserve performance**
- **Minimum maintenance requirements**
- **"On-channel" stability**
- **Crisp, clear voice reproduction**
- **Rugged construction**
- **Dependability through the years**

Twin-V RADIOPHONE 6 12

These and many other features have made "TWIN-V" radiophone the choice of most mobile radio users—features which become more strikingly evident as experience continues to prove their merits.

And Motorola is your *complete* supplier—with the proper equipment for every radio system, plus parts, maintenance, financing, service and engineering available for every application. Write, phone or wire—TODAY!

MOTOROLA

2-WAY RADIO

MOTOROLA COMMUNICATIONS & ELECTRONICS, INC.
A SUBSIDIARY OF MOTOROLA, INC.
4501 AUGUSTA BOULEVARD • CHICAGO 51, ILLINOIS

Motorola consistently supplies more mobile and portable radio than all others combined.
Proof of acceptance, experience and quality.
The only COMPLETE radio communications service—specialized engineering . . . product . . . customer service . . . parts . . . installation . . . maintenance . . . finance . . . lease.
"The best costs you less—specify Motorola."

Pipeline industry's installed at

TURBINE CONTROL is centralized in one convenient, easily accessible location. One switch initiates automatic starting and stopping sequence for the drive system.

VERSATILITY of General Electric gas turbines permits installation of ducts and pipes below floor level. Higher rated gas turbine units provide lower over-all costs.

largest horsepower gas turbines Texas Eastern's Athens, Ohio station

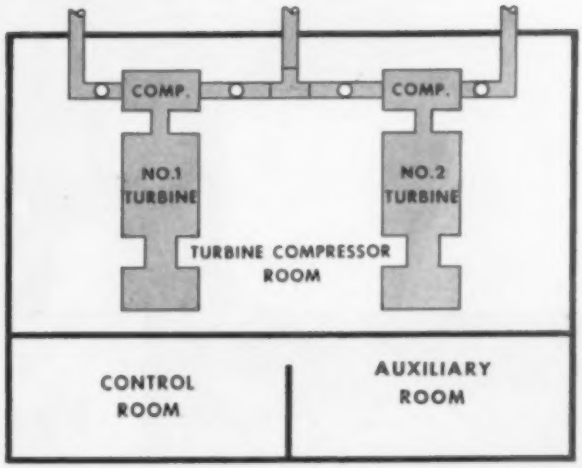
General Electric 7600-hp gas turbine drives provide lower dollars-per-horsepower installed cost, reduced operating costs with improved combustion system

Installed in Texas Eastern's Athens, Ohio station are two of the largest gas turbine units ever used to drive gas pipeline compressors. The new station, one of two duplicate stations put on stream by Texas Eastern, also has other unique features helping to provide efficient operation as well as station flexibility.

TURBINE HORSEPOWER: Each one of the two gas turbines in the General Electric drive system is a 7600-hp unit, largest ever used on gas pipeline applications. These new and larger units provide a lower $-per-horsepower installed cost because there is more horsepower in a given space. In addition, these General Electric turbines operate at better efficiency due to an improved combustion system.

STATION ARRANGEMENT: The new station's regenerator and air filters are located to the side of each turbine rather than axially in line with the turbines. This arrangement permitted straight through piping between compressor units with corresponding minimum pressure losses. A neat installation, with all pipes and ducts running below the floor, was also accomplished. There is no sacrifice in the ability to easily expand the station when load requirements demand it.

TO HELP YOU SOLVE your station drive requirements, General Electric makes available to you complete engineering services. As with the Texas Eastern installation, G-E engineers will help design and install the drive system that exactly meets your station requirements. Get complete information from your nearest General Electric Apparatus Sales Office—and meanwhile write for bulletin GEA-5516B, "Combustion Gas Turbines," to General Electric Co., Section 661-55, Schenectady, N. Y.



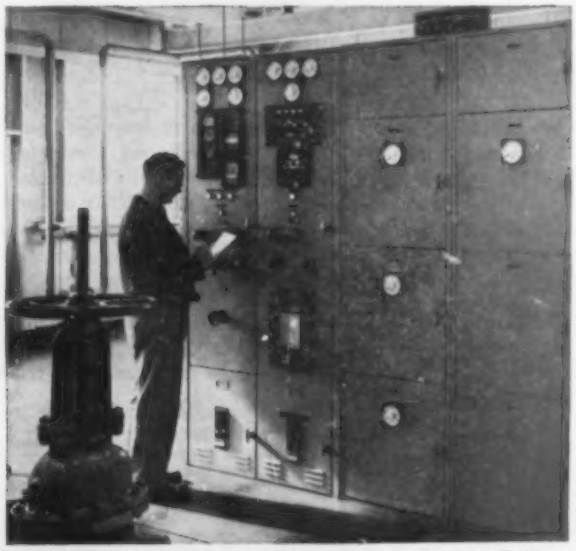
STRAIGHT PIPE reduces to a minimum pressure loss between units. Both of new stations utilize straight piping and, in addition, place station's air filters and regenerators to the side, rather than axially in line with the G-E gas turbines.

*Registered trade-mark of General Electric Co.

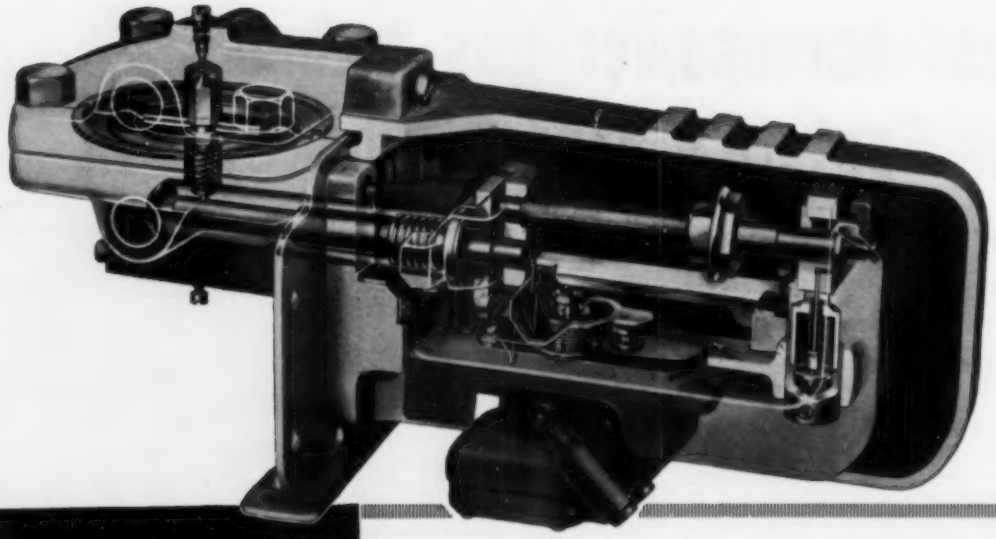
Engineered Electrical Systems for Pipeline Pumping

GENERAL ELECTRIC

MORE EFFICIENT General Electric gas turbine drive system was the result of close co-operation between Texas Eastern personnel and General Electric Company engineering services.



COMPACT, FACTORY ASSEMBLED General Electric Cabinetrol* panels centralize station's auxiliary equipment, are designed to take up minimum of station's valuable floor space.



For full-range control of flow and liquid level

...there are now three HONEYWELL *Differential Converter* models

1. *For measuring gas and water flows:* The new model has a range of 0-5 to 0-25 inches of water. It can also be adapted to the measurement of specific gravity of liquids in open tanks.
2. *For measuring liquid level in closed tanks:* One model has a range of 14 to 50 inches of water, with maximum suppression of 75 inches. Another model, with a range of 50 to 200 inches of water, has maximum suppression of 200 inches.
3. *For measuring flow and liquid level in open tanks:* Two models with ranges from 0-20 to 0-200 inches of water differential and 0-100 to 0-1000 inches.

A mercuryless remote pneumatic transmitter with a range that is continuously adjustable between 0-5 and 0-25 inches of water has just been added to the Honeywell *Differential Converter* line. Now you can choose a standard transmitter for any range from 0-5 to 0-1000 inches of water . . . a choice of ranges offered by no other manufacturer.

The *Differential Converter* measures gas and liquid flow or liquid level with accuracy within ±1% . . . and with rapid response, upscale and down. Range is continuously adjustable in the field, without parts change, and field calibration check is easily accomplished with weights. Air consumption is extremely low.

Compact and lightweight, these transmitters can be mounted anywhere. They're ideal companions for Honeywell *Tel-O-Set* miniature instruments. Call your nearby Honeywell sales engineer for details. He's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Phila. 44, Pa.—in Canada, Toronto 17, Ontario.

● **REFERENCE DATA:** Write for Bulletin 2280-1, "*Differential Converter* Liquid Level Transmitter"; Catalog 2321, "Flow Meters," and Specification 248, "*Differential Converter* Flow Transmitter."

MINNEAPOLIS **Honeywell**

BROWN INSTRUMENTS

First in Controls

SERVICE PIPE LINE'S 625-MILE "BIG INCH"

from Wyoming to Missouri contains 45,000 tons of NATIONAL SEAMLESS

Pipe welders at work on the rolling fields of Kansas.

USS National Seamless Pipe—45,000 tons of it—in sizes 20", 22", and 24" O.D. are now helping to carry millions of barrels of crude oil from the Rocky Mountain producing areas to midwest refining centers.

Starting at Fort Laramie, Wyoming, the new line runs through the Denver-Julesburg Basin of Colorado and Nebraska and is linked to west Kansas producing fields. It ties into Service Pipe Line Company's main North-South system at the western edge of Missouri.

The present outlet capacity is 160,000 barrels per day. It can be economically expanded to 245,000 barrels per day. Initially, more than 1,500,000 barrels of oil were required to fill the line.

The installation of this line brought about a new pipe-laying record—an average of over 10 miles a day. Eight spreads welded as high as 108.6 miles of pipe in one week, and up to 17.4 miles in a single day! This is a tremendous accomplishment in view of the fact that the line passes under 49 highways, countless roads, 21 railroads, eight major rivers, and spans innumerable irrigation ditches.

A section of 24" O.D. x .500" wall National Seamless Pipe, coated for the Solomon River crossing. The covering consisted of a dope primer impregnated with fibre glass paper and coated with two inches of cement.

This type of rugged service calls for exceptionally strong, uniform, flexible pipe that will endure crushing underground and underwater stresses. And most important — it must be pipe that can be depended upon to give long, trouble-free service. This is USS National Seamless Pipe, "Walls Without Welds" . . . and these are the reasons why it is chosen so consistently to do the job.

In Pipe Lines Too . . . Seamless Does It Better

NATIONAL TUBE DIVISION UNITED STATES STEEL CORPORATION, PITTSBURGH, PA.

COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO, PACIFIC COAST DISTRIBUTORS • UNITED STATES STEEL EXPORT COMPANY, NEW YORK

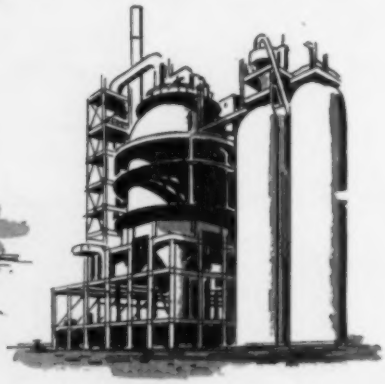
USS

NATIONAL SEAMLESS PIPE AND TUBES

UNITED STATES STEEL

American Hammered Piston Rings . . .

field-tested money savers!



Why not specify piston rings that have *proved* themselves? Koppers rings have been saving money and cutting costs for years—throughout the oil and gas industry, the marine industry, on major railroads, all over the chemical field, throughout the aircraft business, in municipal and industrial power plants everywhere—wherever you find gas, Diesel or steam engines, pumps, compressors, forging hammers—*wherever piston rings are needed!*

They're built to take it . . . designed to cut downtime and maintain high compression . . . give longer, more satisfactory service . . . save you money on fuel and lubricating oil . . . *and that's exactly what they do.* And Koppers rings are available in all types, all sizes—from ½" to 10' diameter—specifically designed for the job they will do in the field where they will be used.

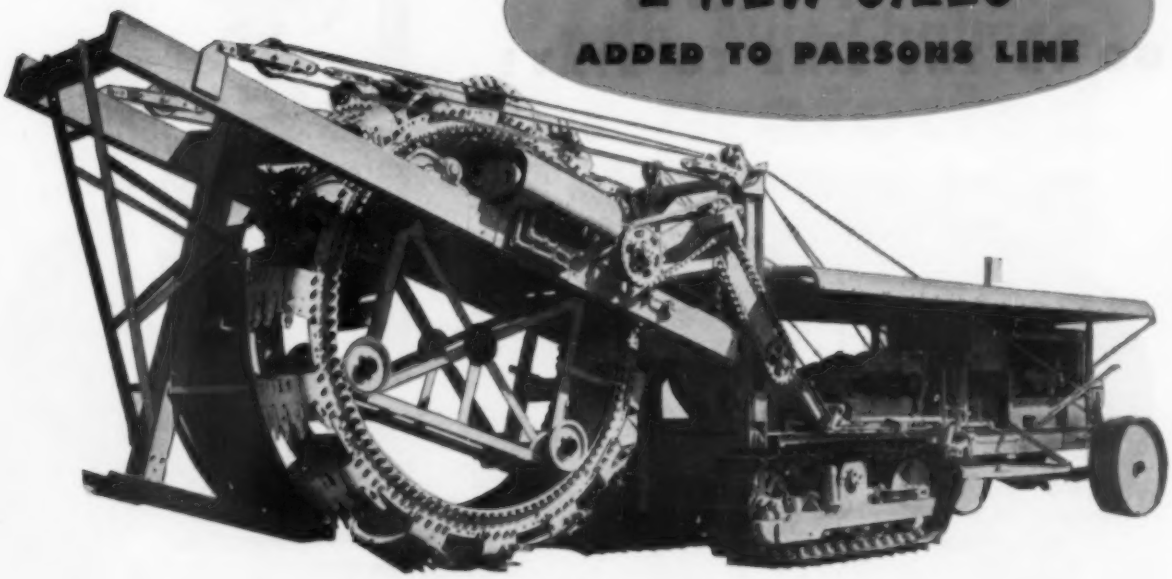
Always specify American Hammered Piston Rings. Benefit from over 100 years of experience in metal products. Use Koppers' complete engineering and metallurgical staff. Get skilled analysis of your specific problem, and prompt assistance. For 16 page Piston Ring booklet write to: KOPPERS COMPANY, INC., *Piston Ring & Seal Dept.*, 1707 Hamburg Street, Baltimore 3, Maryland.

METAL PRODUCTS DIVISION • KOPPERS COMPANY, INC. • BALTIMORE 3, MD. This Koppers Division also supplies industry with Fast's Couplings, Industrial Gas Cleaning Apparatus, Aeromaster Fans, Gas Apparatus.
Engineered Products Sold with *Service*

KOPPERS

AMERICAN HAMMERED
Industrial Piston Rings

2 NEW SIZES
ADDED TO PARSONS LINE



BIG-INCH 520 .... AND MIDDLE-INCH 420

Rounding out a complete line of *Trenchliners for pipeliners,* Parsons now brings you two big, wheel-type machines — both *job-proved* on cross-country work:

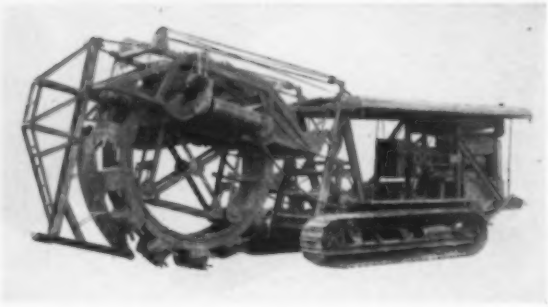
Big-Inch model 520 opens up to 28 lineal feet of trench per minute, depending on depth, width requirements, and working conditions. It digs from 40 to 52 inches wide — and as deep as 8½ feet.

With Parsons Middle-Inch 420 Trenchliner, you get digging speeds up to 44 lineal feet per minute — trench widths from 31 to 46 inches, and depths to 7½ feet.

Originally developed by C-R-C, and now built by Parsons, these two big-wheel ditchers bring you the combined engineering know-how and services of both firms. It will pay you to get more information on these heavy-duty Inchers.

Other Trenchliners in the Parsons line include smaller wheel-types (new 170 shown at right) — and ladder-types on rubber or crawlers, in a complete selection of sizes to serve all your needs. Contact your Parsons distributor or write for literature *today.*

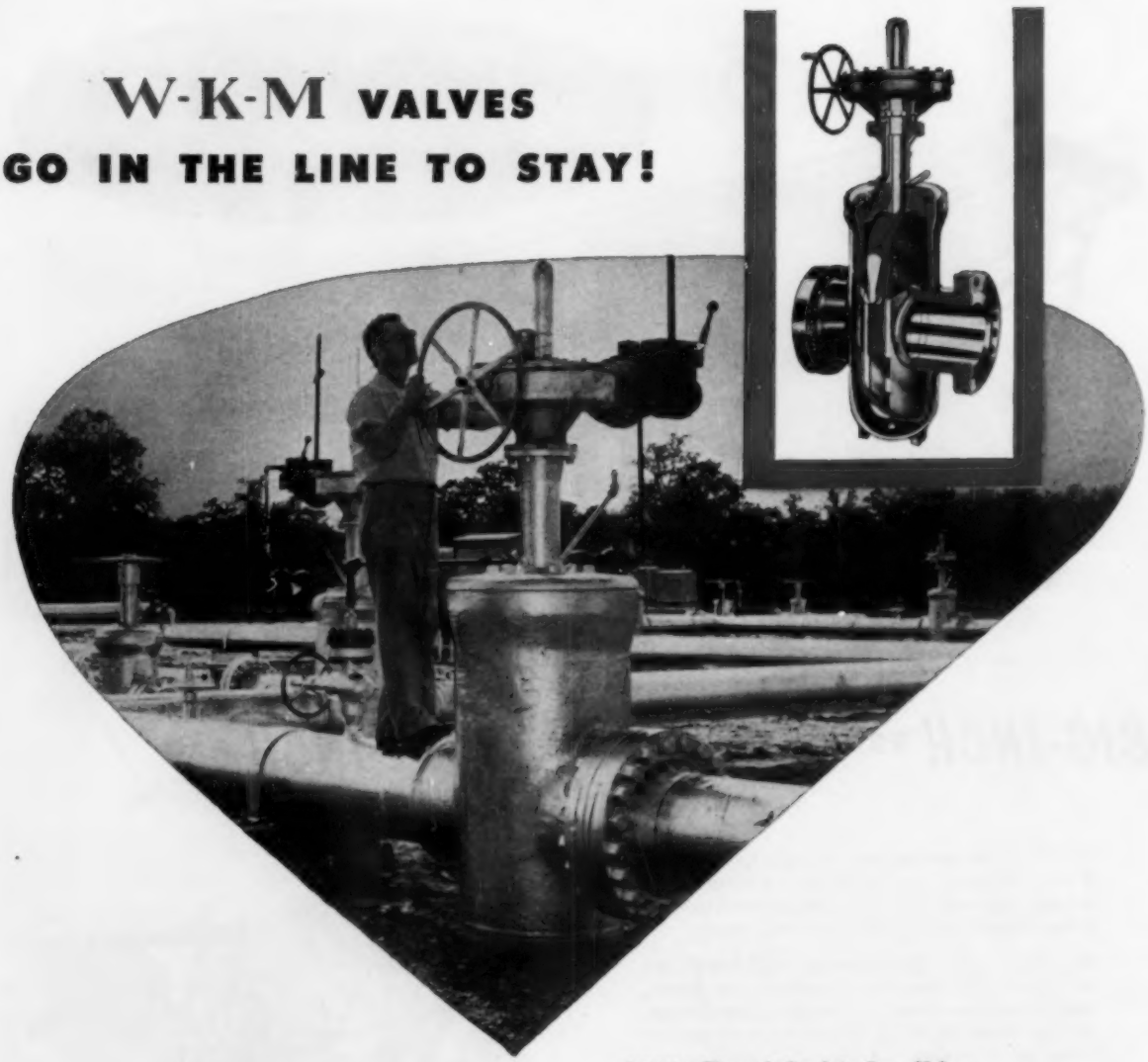
PARSONS COMPANY • Newton, Iowa
A division of Koehring Company



Another recent addition to Parsons line is the new 170 — a medium-size ditcher with extra-wide wheel frame. It digs 20 to 32 inches wide, at depths to 5¾ feet — has hydraulic wheel-hoist on power-tilt mast. Conveyor is hydraulically driven. Belt speeds are completely independent of digging wheel speeds.

TRENCHLINERS® for PIPELINERS

W-K-M VALVES
GO IN THE LINE TO STAY!



W-K-M
DIVISION OF **ACF** INDUSTRIES
INCORPORATED
PLANT: MISSOURI CITY, TEXAS
MAILING ADDRESS: P. O. BOX 2117, HOUSTON, TEXAS

9702

W-K-M Through-Conduit Gate Valves stay "in the line" because their superior design provides free and easy operation, positive seal under any pressure, and freedom from turbulence and destructive erosive action.

They stay "in service" when and if repairs are necessary. Gate and segment, seats, stem, bonnet, seal ring, and clamp ring can be removed and replaced without removing the valve from the line.

For valves that stay in service and in the line year after year, specify **W-K-M** Through-Conduit Gate Valves.

W-K-M ASA Through-Conduit Valves are available in sizes 2″ through 30″—ASA 300 lbs. to ASA 900 lbs. Valves up to 12″ are available through Supply Stores.

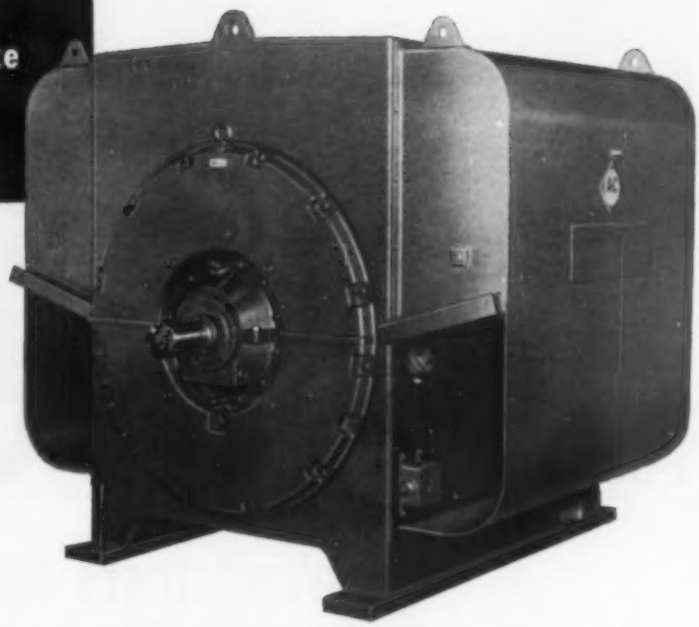
Bring your valve reference library up to date by writing Dept. G-701 for new W-K-M ASA Through-Conduit Gate Valve Catalog 300.

MANUFACTURERS OF W-K-M GATE VALVES · ACF LUBRICATED PLUG VALVES · KEY-KAST ALLOY STEEL PIPING FITTINGS · KEY RETURN BENDS AND FITTINGS

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Eliminate costly enclosures with Allis-Chalmers weather-protected MOTORS

Modern features
cut operating, maintenance expense . . . give MORE dependability



Here's a newly designed line of Allis-Chalmers weather-protected motors with the ability to "take" outdoor conditions. This means no expensive protective enclosures are needed . . . a big saving in plant or installation building costs.

Designed to meet defined NEMA requirements, these motors incorporate many important features which assure dependable outdoor operation:

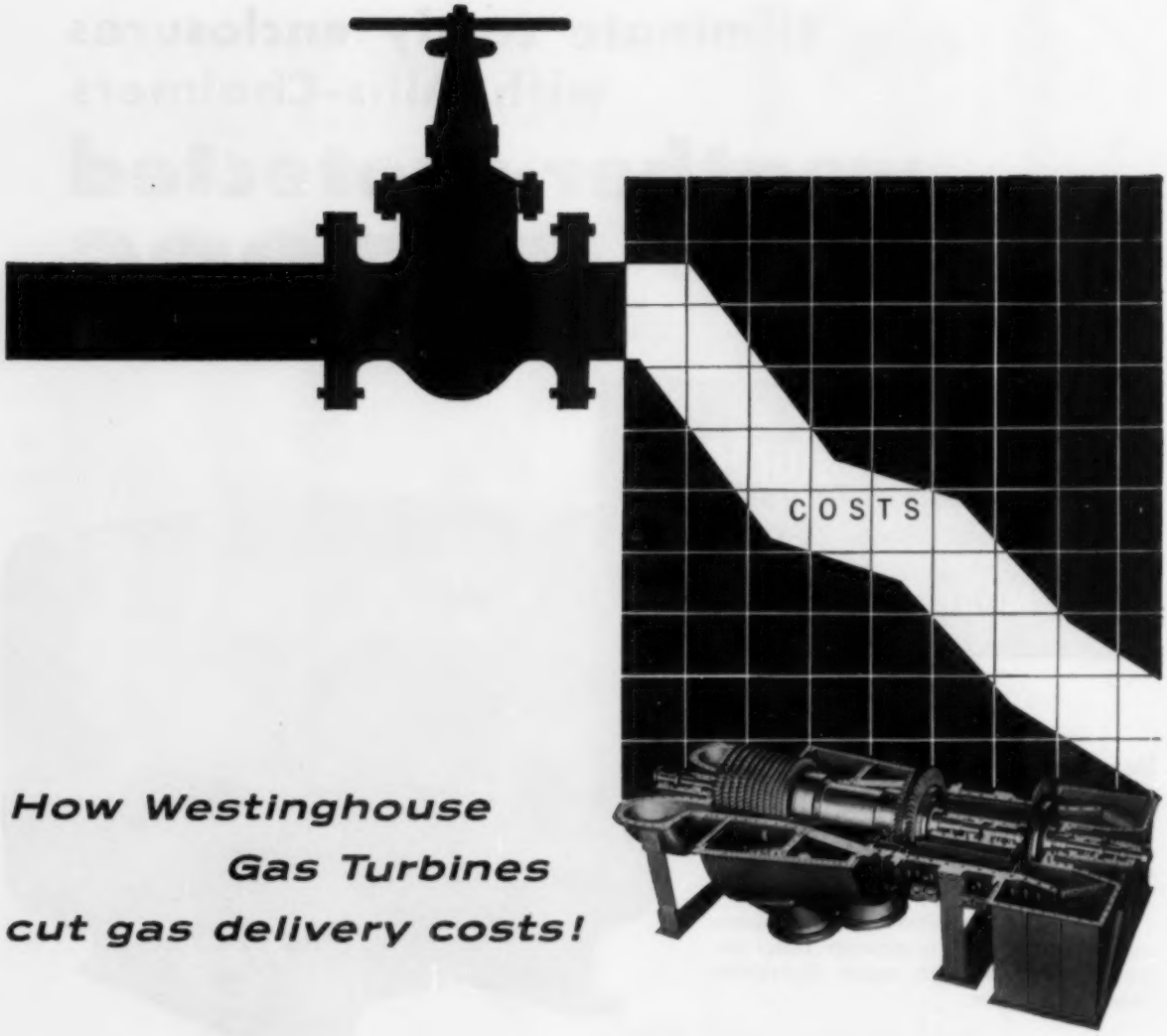
- **Ventilating System** — Low velocity intake, vertical lift, change of direction and high velocity discharge of ventilating air keep rain, snow, sleet, dust and dirt out of vital parts.
- **Removable Air Ducts** — To facilitate inspection and maintenance of interior air passages, air intake ducts are designed for quick removal.
- **Stator Assembly** — Removable as a unit, it simplifies maintenance and minimizes downtime.
- **Split Sleeve Bearings** — Capsulized design permits access to motor interior without disturbing the bearings or their enclosures. Positive vapor seal is used on high-speed motors. Antifriction bearings are available for slow speed motors.
- **Proven Insulation** — Famous Allis-Chalmers insulation systems (Class A and B) are available. And, for extreme temperatures, or where high resistance to abrasion and moisture is required, Allis-Chalmers can provide the revolutionary *Silco-Flex* system.

Silco-Flex is an Allis-Chalmers trademark.

THIS DESIGN available in ratings from 250 to 900 hp. Other designs in larger horsepower ratings are also available. Contact your A-C sales office or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin. Ask for Bulletins 51B8606A and 05B7894.

A-5292

ALLIS-CHALMERS



How Westinghouse Gas Turbines cut gas delivery costs!

EACH MONTH, MORE WESTINGHOUSE gas turbines are being installed for gas transmission. These orders indicate it's time to take another look at the savings offered by the modern Westinghouse gas turbine for pipeline pumping! Here's what you get:

Extra hp during cold weather—Up to 25% more horsepower . . . when you need it most!

Lower initial cost—based on unit horsepower, not considering the extra 25% during cold weather. And, usually, no reduction gear is needed.

Lower station structure cost—The gas turbine weight is less than 45 pounds per hp and the vibration level is low.

Simple maintenance—Lifting the cover exposes the entire gas turbine for inspection . . . a feature pioneered by Westinghouse.

Low operating costs—Minimum man power and low lube oil consumption are just two of the many operating cost advantages.

No cooling water needed — Eliminate water-handling problems and risk of water supply failure.

Challenge us to prove that the modern Westinghouse gas turbine can cut your gas transmission costs. Contact your Westinghouse representative or write to Westinghouse Electric Corporation, P. O. Box 868, Pittsburgh 30, Pa. J-50601

YOU CAN BE SURE...IF IT'S Westinghouse

Plantation's new 18" pipeline carries gasolines, kerosenes, diesel and fuel oils 327 miles from Baton Rouge, La., to Helena, Ala.

Blue Flag helps protect Plantation's new 18" pipeline against corrosion

By using glass fiber mat to reinforce the enamel coating, Plantation Pipe Line Co. helped give longer lasting protection against corrosion to its new line, tapping the Gulf Coast for southeastern markets. Blue Flag Pipe Wrap was used on approximately 100 miles of this project.

L·O·F Glass Fibers' Blue Flag guards pipelines against corrosion by strengthening protective enamel, and increasing its resistance to soil stress and backfill damage. Its uniform porosity allows enamel to bleed through quickly, lets trapped gas escape easily. Result: far fewer "holidays" and greatly increased pipeline service life. Cost: less than ½ of 1% of initial investment.

Blue Flag Pipe Wrap is made from inert glass fibers which resist the action of soil chemicals. And its high tensile strength virtually eliminates breakage in the field and resulting time loss.

For long-lasting pipeline protection at low cost, insist on Blue Flag reinforcing inner-wrap for your over-the-ditch and yard-wrapped pipe. Your nearest distributor gives fast delivery. For his name, or for full technical information, write today: *L·O·F Glass Fibers Company, Dept. 72-77, 1810 Madison Ave., Toledo 1, Ohio.*

L·O·F GLASS FIBERS

L·O·F GLASS FIBERS COMPANY · TOLEDO 1, OHIO

HOW BELL SYSTEM COMMUNICATIONS SERVE THE PIPELINE INDUSTRY

CARROLL V. KROEGER, *distribution engineer, Washington National Gas Company, Seattle, Wash.*

"How we know when to interrupt our interruptibles"

Remote metering lines give Washington Natural Gas a 24-hour headstart on determining contract demand

"To stay on the profitable side of our contract, we need continuous readings of flow to determine customer demand—the difference between flow measured at city gates, and supply to our interruptibles," says C. V. Kroeger, Washington Natural Gas.

"Bell System remote metering lines give us these readings. Here in our Seattle office, meter readings from 75 remote points enable us to calculate flow at all gates and project demand over the next 24 hours. Thus we know when to interrupt our interruptibles —or tap our 'peak shaving' reserve.

"Why do we lease lines from the Bell System? For one thing, the service is economical—no capital investment is needed. And telephone men maintain the lines, so we don't have to train new men for our staff. But mainly, Bell service is reliable. We know we can count on it."

• • • •

A Bell System representative will gladly study your communication needs—at no cost, of course—to show how you can get these benefits. Just call your local Bell Telephone Company business office.

BELL TELEPHONE SYSTEM

PRIVATE LINE TELEPHONE • PRIVATE LINE TELETYPEWRITER • DATA TRANSMISSION SYSTEMS
CHANNELS FOR: REMOTE METERING AND CONTROL • TELEPHOTOGRAPH • CLOSED CIRCUIT TV

Dual Control System Built Into Badger's Middlebury Station

Two suction sources and widely divergent pressures and flow rates dictated both fully automatic and manual operation

Gene Wooster and Joe Purvine
Engineering Department
Cities Service Oil Company

BADGER Pipe Line Company added two new pumping stations to its system during 1956.

At Des Plaines, Illinois, a station consisting of two 300-hp units was installed adjacent to the existing metering station to boost products originating at East Chicago, Indiana, and Lemont, Illinois, to Rockford, Illinois, and Madison, Wisconsin.

The other station, consisting of two 250-hp units, was installed at the existing Middlebury metering station to boost to Rockford and Madison products originating at Peru, Illinois, and those received from Great Lakes Pipe Line Company at Middlebury.

Des Plaines station was designed for manual operation since metering station personnel would be in attendance when the station was pumping.

At Middlebury, however, the station would be unattended except when receiving products from Great Lakes. Receipts from Great Lakes are metered into the Badger system and both Badger and Great Lakes personnel are present during the custody transfer.

Two suction sources at Middlebury and their widely divergent pressures and flow rates introduced complexities in control design.

The problem was this:

Should the station be designed for remote control, using Badger's CTC control system, then pressures, flow rates, interfaces, motor currents, etc., would have to be telemetered to the dispatching office. This, of course, would require extensive modification of the present mimic control board and would, in addition, involve considerable rental for leased channels.

Cities Service Oil Company is the operator of the jointly-owned Badger Pipe Line Company system. Other owners are Sinclair, Texas, and Pure.

Because of these factors, and the further fact that remote control would be in effect only when boosting the Peru stream, it was decided to design for completely automatic operation and to provide a manual control system for use when boosting the Great Lakes stream.

In designing for automatic operation, various advantages and disadvantages of flow and pressure characteristics were weighed to determine the source from which the necessary signals for station control would be derived. A study of contemplated operating conditions revealed that rate of flow would provide more reliable signals for starting and stopping operations than would pressure. It was also determined that pressure control would better monitor and regulate the station.

Hence, the operation of the station is controlled automatically by a combination of flow and pressures.

Each of the two pumping units consists of a multistage vertical pump driven by a 250-hp, 3600-rpm, 2300-v motor with Class B insulation. Suction valve of each unit is manually operated (left open, normally) and, when fully open, actuates a limit switch in its unit control circuit. Discharge valve of each unit is electrically operated in sequences with the pump motor.

The station incoming-line breaker, the unit motor starter breakers and auxiliary equipment are contained in a metal-clad outdoor switchgear lineup. Circuit breakers are air-break, rectified a-c close and d-c trip.

Prime station control element is an instrument-responsive, electrically-operated control valve.

Input signal to the valve positioner of 0.5 to 5.0 milliamperes d-c is derived from the suction and/or discharge pressure electronic transmitters through their respective recorder-controller instruments. The valve is normally positioned by the suction pressure controller, but, in case of excessive line pressure, the discharge pressure controller overrides. Both the suction and discharge pressure controllers are equipped with proportional, rate and reset sections.

Intelligence to start or stop either or both of the pumps is devised from the flow transmitter. This unit, a cell actuated-balanced beam electronic transmitter, outputs a 0.5 to 5.0 milliampere d-c signal to a series circuit of two current sensitive precision relays and a flow recorder. Relays are adjustable to permit actuation at any current level in the 0.5 to 5.0 milliampere range. Each of these relays controls the on-off operation of one of the pumps at a predetermined flow rate. Thus the operator at Peru station can start and stop the units at Middlebury by increasing and decreasing the flow rate at Peru.

The station is protected against low suction pressure by an adjustable time-delay trip-out, which works as a back-up to the station control valve. Should the valve fail to operate, or fail to throttle the station quickly enough to maintain a minimum suction pressure, the low suction pressure unit will shut the

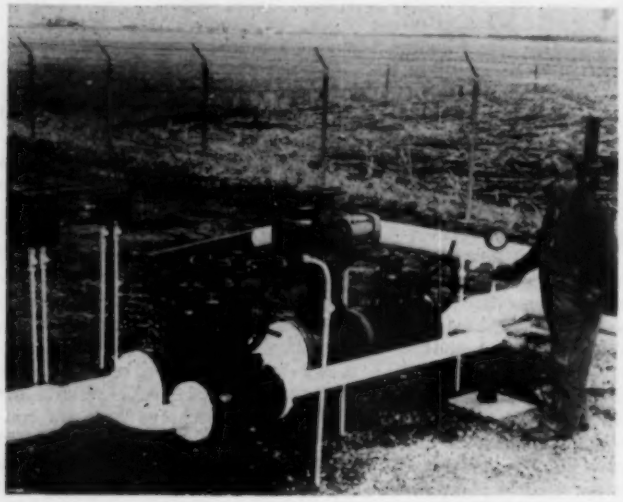
The Authors

A. E. Wooster, project engineer, Engineering Division, was first employed by Cities Service Oil Company in its Gasolene Division, in June 1934. Construction, operations, and valuation were his fields of activity until September 1936 when he was transferred to the Engineering Division. Since then he has been resident engineer and project engineer on pipeline, gasoline plant, and refinery construction projects.

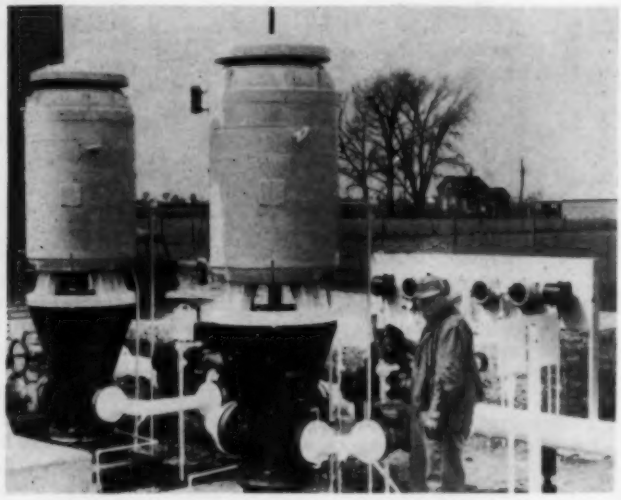
J. M. Purvine, electrical engineer, Engineering Division, Cities Service Oil Company, received a BS degree from Oklahoma A&M in 1950. He went to work in the Geophysical Department of Cities Service in February of that year and was transferred to the Engineering Division in August. His activities now are in the design of electrical facilities, instrumentation, and controls in connection with new construction for all operating divisions of the company.

General view of Middlebury station showing pumps and Jib Crane on the extreme right; meters, strainers, prover tank, and other equipment in the center; control room portion of the building on the left, and although it is not shown, the switchgear is just barely out of the picture on the extreme left.

J. W. "Jud" Smith of the Bartlesville engineering department at the panel containing instruments that control operations of the pumps. The two boxes below the instrument panel contain relays by means of which the Badger dispatcher can ready a pump for operation or prevent its operation merely by dialing a number on his teletype machine.

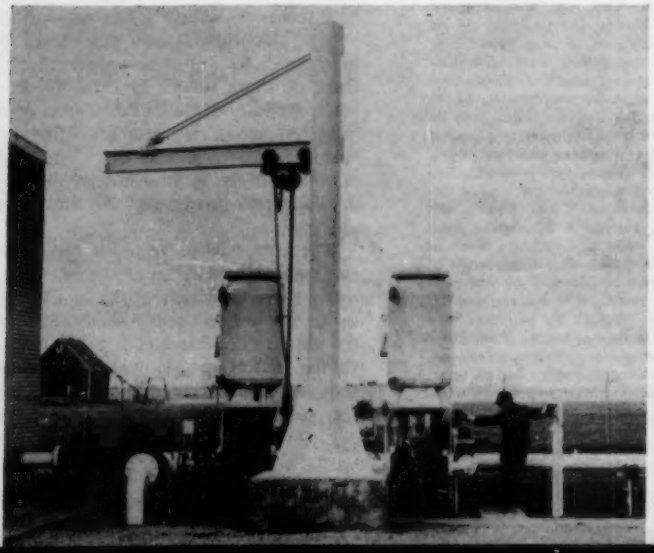


Millard Henson, Badger employee of the Rockford District, at the electrically operated control valve, which throttles the stream at this station. The line entering the ground beyond the control valve is the 8-in. main line going toward Rockford, Illinois.

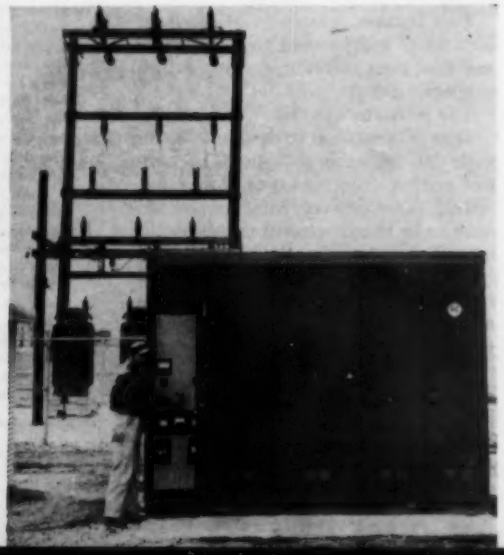


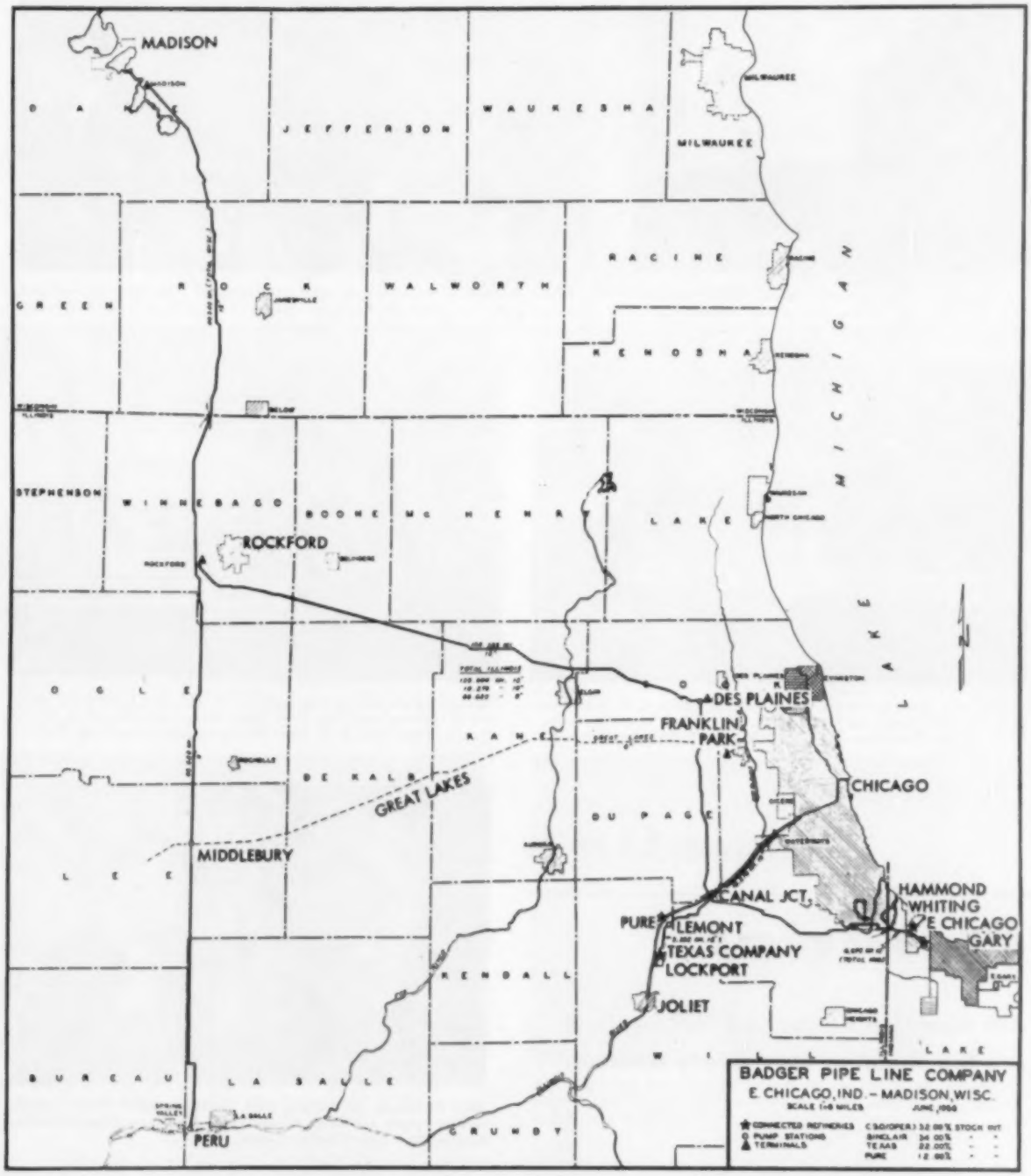
Millard Henson again, this time standing near the two 250-hp pumps at Middlebury station.

Another view of the two pumping units with R. H. Coldren in the picture. The Jib Crane used to remove the motors and pumps, whenever it is necessary to do so for the purpose of effecting repairs, is shown between the two pump motors.



Frank Humphreys standing at one of the cubicles comprising the group of switchgear that contains the starters and other auxiliary electrical equipment for controlling the pump motors.





station in.

In conjunction, also, with the discharge pressure override on the control valve, a mercoid switch on the downstream side of the control valve acts to shut the station in if line pressure exceeds a set maximum.

A degree of remote control has been incorporated in the automatic operation by the addition of selectors in the teletype equipment. The dispatcher is thus provided with a lockout for either or both units. Likewise, he can dial either or both units on.

Each pump-motor unit is individually equipped with trip-out protective devices that function on over-temperature and abnormal vibration conditions. The vibration monitor, when caused to operate, establishes a lockout for that particular unit.

Middlebury station is tied into the Badger teletypewriter net and relies entirely upon that medium for communication with the dispatcher and other Badger stations. Private line telephone connects Middlebury with the Great Lakes dispatcher.

As stated, when Middlebury is boosting the Great Lakes stream the station is attended. At these times the station may be operated automatically or locally by the manual control system. This system is essentially the same as that for automatic operation. The only major variable is that of manually increasing or decreasing the signal to the control valve to maintain station regulation. ★ ★ ★

Pipeline

Pictorial

API Pipe Line Conference in Cleveland
. . . The shooting was strictly informal

John de Groot, president of Tuscarora Pipe Line Company and chairman of the Conference Steering Committee, calls the first session to order.

Speakers at opening session: N. B. Mavris, Continental Pipe Line (on rostrum); George Hughes, Interstate Oil Pipe Line, who presided (at his left); O. A. Ohmann, Standard of Ohio; D. C. McKinley, Interstate.

Members of Monday's panel session (left to right): L. R. Dickinson, Trans-Northern Pipe Line; Max T. Nigh, Service Pipe Line; Ben Leuty, Cities Service Pipe Line; M. S. Collett, Atlantic Refining Company;

Earl W. Unruh, Sinclair Pipe Line, moderator; Sam L. Jackson, Standard of Indiana, presiding; E. A. Slade, Okan Pipe Line; W. L. Moore, Humble Pipe Line; J. R. Ellis, Oklahoma Mississippi River Products Line.

Does somebody not believe what somebody said? These skeptical looking people are Ralph Moore, Platte Pipe Line; Charles Ashmun, Buckeye Pipe Line; Charley Carter, Sinclair.

Relaxed between sessions are S. A. Click, Ohio Oil; P. H. Phillips, Jr., Humble Pipe Line; R. M. Slough, Ohio Oil.

Two old hands at the convention racket: Charley Keane, Great Lakes Pipe Line, and Lou Scherer, Texas Pipe Line.

Contractor and operators get together: David R. Williams, Williams Brothers; Ben Winters, Southeastern Pipe Line, and Al Horne, Texaco-Cities Service.

A lot of operating brains represented here: George Brigance, consultant; L. B. Moon, Sinclair; A. E. Pecore, Humble; F. A. Crane, Sinclair, and Gerry Johnson, Sinclair.

Fred Warren, Ohio Oil; Earl Unruh, new Sinclair Pipe Line president, and V. G. Murdock, Allis-Chalmers Mfg. Company.

Ben Leuty, recent'y elected president of Cities Service Pipe Line, talks it over with fellow townsman Vice President W. H. Wallace of Phillips Pipe Line.

L. R. Dickinson, president of Trans-Northern, and Ralph Dougherty, general superintendent of Minnesota Pipe Line, seem to enjoy having their picture taken.

The shutter clicker interrupts a conversation between Allen Baxter, Atlantic Pipe Line; R. P. Lennart, Service Pipe Line, and R. H. Lynch, Atlantic.

We don't even know whether the sale of pipe was involved, but here are J. W. Chanda (left) and H. D. Loisenring of A. O. Smith Corporation, talking with A. L. Christy (center), Transportation Engineers.

Pipeline Pictorial

Millard Neptune (left) could be relating an interesting experience to his brother, F. B. Neptune, and C. W. Hubbell, both of Phillips Pipe Line. Millard recently resigned as general manager of Sahara Petroleum in Egypt to become executive vice president in charge of products pipe lines for Texas Eastern Transmission Company.

Hugh Baird, president of Standard Pipeprotection, with Charles F. Firman of Ohio Oil.

Charles Younts (right), president of Plantation Pipe Line, and Wendell Ramsey, Gulf Oil, meet in the lobby.

Certainly it was funny. These goodhumored fellows are Jim Ford, Sun Pipe Line; Gil Armour and John Casner of Youngstown Sheet & Tube.

Friendly competitors: Pete Markle, WKM Division of ACF Industries, and Buck Carlson, Rockwell Manufacturing Company.

Russell Brannon of Humble Pipe Line and George Hughes of Interstate Oil Pipe Line look at the birdie.

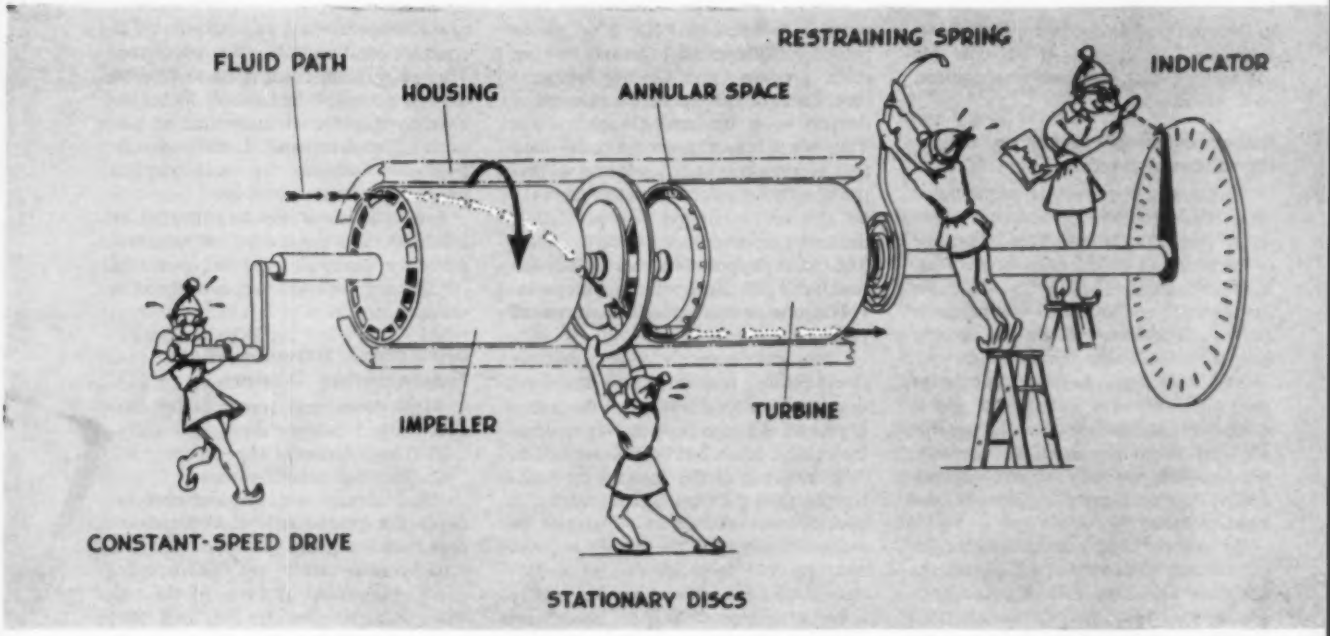


FIG. 1. **Mass flowmeter principle.** Impeller turns at constant speed — 60 to 120 rpm. Gas is given a twist. Its effect on restrained turbine is function of weight.

The future is here, today . . .

How Mass Flowmeters Measure Gas

Forget temperatures, pressures, differentials, etc., and measure gas by its weight, say authors. New meter promises unusual accuracies.

Lawton L. Laurence,
Black, Sivalls & Bryson, Inc., Oklahoma City, Oklahoma,

Charles M. Halsell,
Black, Sivalls & Bryson, Inc., Oklahoma City, Oklahoma,

and

John R. MacIntyre,
General Electric Company, West Lynn, Massachusetts

WHAT is the ideal way to measure gas? Perhaps the best way would be to count the exact number of molecules that pass by a particular metering point. Another would be to total the exact number of Btu's the gas can develop when it burns.

Such ideal precision in gas measurement may be a long time coming, but mass flowmeters now under test actually provide an accurate approach to measuring both of these quantities. Actually, the weight of a given volume of gas is a function of the number of molecules present. This, in turn, is a function of the heat content of the gas stream present where the gas is of modern day pipeline quality.

Thus, if we can measure the weight of gas accurately, we are in reality measuring both the number of molecules and Btu content of the gas.

In the infancy of gas metering, the primary elements that were available to industry fell into one general category: Those most suitable for metering gas on the basis of volume. Therefore, it became standard practice to meter gas on the basis of its volume at a specified pressure and temperature. All subsequent metering devices were designed and calibrated with this parameter as the object of their indication. The regulating bodies in several states have established base or contract conditions of pressure and temperature at which the volume is to be measured. Unfortunately, these conditions are not uniform. Non-uniformity exists within those states which have no contract conditions although the AGA recommends base conditions.

By requiring that certain conditions be established before a quantity of gas may be measured, a basic inadequacy

Paper presented at the Southern Gas Association's 12th Annual Short Course in Gas Technology at Texas A & I, Kingsville, Texas, May 29 to 31, 1957.

in the metering device is implied. However, the industry has lived with this for so long that it is rarely recognized as a weakness.

Advantages of Metering on the Mass Principle

There is an approach to metering of natural gas that does not require established base conditions. This technique of metering is called mass flow measurement and is based on the principle of measuring the mass (or what is more commonly thought of as the weight) of gas being metered.

This technique has the advantage that the mass of a quantity of gas is completely independent of its variable physical properties such as pressure, temperature, viscosity, supercompressibility, specific gravity, turbulence, and linear velocity.

By comparison, conventional volumetric standards rely upon corrections for these variables, i.e., supercompressibility data to correct the calculations for the deviation of the gas from the ideal gas behavior. AGA Report Number 3 lists supercompressibility data for natural gas of 0.60 specific gravity as a function of pressure and temperature. The AGA has prepared separate and extensive tables of supercompressibility factors as a function of temperature, pressure and specific gravity. This supercompressibility data, however, is never exact because:

1. *The data is experimental in nature and subject to error in measurement.*
2. *Impurities in the gas or other deviations in analysis from sample to sample result in a change in the supercompressibility factor. For this reason, most major companies determine the supercompressibility factors of the contract gas experimentally. This technique is not free from error.*

A mass flowmeter is not subject to such corrections because the mass of a quantity of gas is independent of all such variables.

Note that if gas is metered by volume through an orifice installation, the specific gravity must be accurately determined. With these data, volume at standard conditions and specific gravity, the mass or weight of this quantity of gas may be calculated to an accuracy that is only limited by the accuracy of the data used. Similarly, if the mass is known and the specific gravity can be determined, the volume at standard or contract conditions may be calculated. The mathematical operations then are equivalent, but consider the basic manner in which data are collected.

In an orifice installation, the volume must be determined from a meter record of **differential pressure, flowing static pressure,** and **flowing temperature.** Each of these separate measuring devices must be carefully calibrated. The meter chart must be integrated and average conditions selected so that the appropriate correction factors may be selected including the previously discussed supercompressibility factor. **The AGA Report Number 3 lists ten factors in all. Each of these steps involves one or more possible sources of error.**

The mass flowmeter detects, records if necessary, and integrates the total mass rate independent of all the measurements that are regarded as basic to the orifice. Mass has been described as "the measure of the amount or quantity of matter." A mass flowmeter is designed to measure a "quantity of matter" truly and accurately without recourse to a large number of corrective coefficients. The specific gravity may be measured with an instrument of suitable accuracy, and the volume at contract conditions may be calculated. This conversion from mass to volume can be accomplished much more accurately than the measurement of volume by conventional devices; that is true only because the mass may be measured more accurately.

Inevitably mass will be accepted by industry as the standard of measurement for gases and the full potential of the mass flowmeter can then be utilized.

Distinctions Between Mass Flowmetering Devices

Mass flowmeters generally fall into two distinct categories:

1. The inferential type meter
2. The true mass flowmeter

They should not be confused because the latter has a marked advantage over the former.

Inferential meters are used because of the simplicity of form of the primary element plus the fact that they

What Engineers Asked

Here are some of the questions that popped up at the 12th Southern Gas Association Short Course in Gas Technology held at Texas College of Arts and Industries, Kingsville, Texas, May 29 to 31, 1957:

Q. How fast does the impeller turn?
A. Usually about 70 rpm. For different fluids, different speeds can be used.
Q. What drives the impeller?
A. A synchronous electric motor. The current requirement is very small, and you will note that the speed is not great.
Q. What if the current frequency varies — will this affect the measurement?
A. It so happens this was one of the most difficult problems to solve in the development of the meter. The solution came when one of the development engineers devised circuitry in the integrator that nullifies the error in the meter. In other words, if the frequency dropped, say, from 60 cycles to 50, the reading from the instrument obviously would be low. But when this happens, the integrator would give out an error on the high side that would almost exactly balance the error from this source.
Q. What happens if the power source fails and the impeller stops?
A. The meter stops recording. Gas continues to flow, but it is unmetered.
Q. What about dust in the line?
A. The meter will weigh the dust. For that matter it will weigh anything that goes through the

greatly resemble meters that have been used for a long period of time. In the inferential meter it is necessary to use computational techniques to correct the output of the meter for temperature, pressure, viscosity, density, etc. Because advanced computational devices have been perfected over the last decade, it is possible with an inferential meter such as a head or an area meter to correct for the required variables and perform the mathematical operations that will give an output that is an indication of mass flowrate. Combined with a satisfactory integrator or totalizer, the total mass that has passed through the meter in a given period may be registered.

A true mass flowmeter differs basically. A true mass flowmeter produces an output that is linear with mass flowrate and is independent of such variables as pressure, temperature, viscosity, density, ambient temperature, and ambient pressure. If the properties of the fluid and the ambient surroundings do not influence the indication of the true mass flowmeter, then it may be concluded that the accuracy of such a meter will be materially greater over a wider range than an inferential meter, which relays upon appropriate corrections for its accuracy.

The first urgent demands for a mass flowmeter for the metering of liquid was felt with the onset of the jet age in the aircraft industry. A device was needed that would indicate the fuel consumption of jet engines independently of altitude, temperature, and pressure. The obvious answer was a true mass flowmeter. A volumetric meter was unsatisfactory and an inferential type mass flowmeter was too bulky, inaccurate, and subject to failure. The General Electric Company perfected a true mass flow instrument for liquid fuel metering that found wide acceptance throughout the aircraft industry because of its high accuracy, operational simplicity, and long service life. The possibility that a meter of similar design would be suitable for metering natural gas was apparent.

About the New Flowmeter

instrument. But, in most gas lines, the weight of dust is negligible when compared with the weight of the gas.

Q. What about condensate?

A. It will weigh that too.

Q. How about hydrates?

A. If the meter freezes up, it will not measure.

Q. How accurate is the meter?

A. Tests are underway to determine the accuracy. This instrument was first developed to measure liquid fuels in aircraft. It was the most accurate and reliable that could be found for this purpose. There are indications that the meter will be far more accurate than present day meters.

Q. How does it compare with an orifice meter?

A. Various companies claim various accuracies for their meters — balancing purchase and fuel gas meters against sales meters. Regardless of the percentage of correlation in this balance, meters at both ends of the line are subject to the same calculations, which are empirical and subject to many errors. Just think of the errors that must come from planemetering the charts.

Q. How will the cost compare with the conventional meter set-ups?

A. It should run about the same.

Q. Can this meter be tied into control valves?

A. Yes indeed!

Q. The impeller and turbine are shrouded. What is the clearance between the shrouds and the blades?

A. About 500 microns.

Basic Operational Principles of the Mass Flowmeter

The principle of operation of the mass flowmeter is illustrated in an imaginative sketch in Fig. 1. The gas stream enters the impeller, which is driven at a constant speed by a synchronous motor. The gas passes through the straight annular vanes of the impeller and is given an angular momentum. A turbine wheel very similar to the impeller is placed close to the impeller and is restrained by a torque, which can be measured. All angular momentum that has been imparted to the stream by the impeller is extracted by the turbine wheel. The torque that the stream applies to the turbine is directly proportional to the mass flow rate.

A decoupling disk is interposed between the impeller and the turbine. The function of this disk is to eliminate viscous coupling between the impeller and the turbine. The viscous shear forces created by the rotation of the impeller are imposed on the decoupling disk. This practically and effectively eliminates viscous effects upon the turbine.

A thin shroud encloses the vanes of both the impeller and the turbine. This prevents the interchange of fluid across the vanes. The clearance between the housing and the shroud though minimal is large enough to pass solid particles up to 500 microns. The bulk of the gas stream must pass axially through the vaned channels of both the impeller and the turbine.

Basic Theory

The mathematical derivation of the output torque on the turbine is explained as follows:

Considering that the angular momentum imparted by the impeller is removed by the turbine, the torque on the turbine is expressed by:

$$T = \frac{dH}{dt} \quad \ldots\ldots\ldots\ldots (1)$$

Where:

T = torque

H = angular momentum of the rotating stream

This equation is Newton's 2nd Law. Consider a small mass of fluid, dm, which leaves the impeller in the time interval dt. The angular momentum of this small mass can be expressed as:

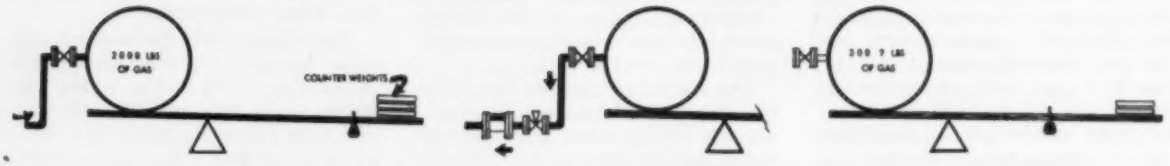
$$dH = WdI \quad \ldots\ldots\ldots\ldots (2)$$

Where:

W = angular velocity of the impeller

dI = mass moment of inertia of the small fluid mass about the axis of the impeller

HOW MASS FLOWMETERS WILL BE TESTED



Fill sphere with gas — weigh it... flow gas thru meter and measure it... weigh gas left in cylinder.

It is convenient to express the mass moment of inertia in terms of radius of gyration, k, which depends mainly upon the distance between the axis of rotation and the center of the passage and only to a small extent upon the shape of the passages,

$$dI = k^2\ dm \quad \ldots\ldots\ldots\ldots (3)$$

Combining equations (2) and (3) and dividing by dt:

$$\frac{dH}{dt} = Wk^2 \frac{dm}{dt} \quad \ldots\ldots\ldots\ldots (4)$$

Note that $\frac{dm}{dt}$ is the mass flowrate (or the rate at which fluid leaves the impeller)

Substituting equation (4) into (1):

$$T = Wk^2 \frac{dm}{dt} \quad \ldots\ldots\ldots\ldots (5)$$

Equation (5) shows that the torque imposed on the turbine is proportional to the mass flow rate, dm/dt, and that the proportionality constant, Wk^2, depends on the angular velocity and the dimensions of the impeller.

Special Advantages

Beyond the advantages of metering on the mass basis, this meter has several special advantages when compared to most other types of gas meters presently available or proposed.

A theoretical mathematical analysis indicates that the output of the General Electric mass flowmeter will be slightly affected by the shape of the flow pattern in the vanes of the turbine. Because of the initial turbulence created at the entrance, however, it is not likely that a laminar flow pattern will be established. Liquid flow tests have indicated that the output is essentially independent of Reynold's Number effects.

Major range changes in this instrument are accomplished simply. Equation (5) indicates that the output torque is directly proportional to the impeller speed. By changing motor speeds, the range may be changed to best suit the application. Minor range adjustments, to make the instrument direct reading, are mechanical in nature as is the zero adjustment.

The calibration of the meter is best accomplished on a prover facility of special design. This prover will differ from conventional flow prover facilities since it must be designed to calibrate on the basis of mass or weight instead of volume. After calibration, the adjustments will be sealed to prevent tampering. The frequency of recalibration will have to be determined from experience. In this manner, the supplier will provide a meter whose calibration will be certified and whose accuracy will have been established far more closely than conventional meters.

Another characteristic of this meter is that its mechanical output is suitable for adding the indications of a number of meters without interferring with the indication of individual meters. Remote indication of the meter is easily accomplished electrically.

The size and weight of the meter is small, which makes for simplicity in installation and maintenance. The size is comparable to a senior orifice fitting without a recorder. Experiments indicate that auxiliary flow straightening devices are not necessary, and this meter may be installed in a confined area. Meter runs common to orifice plates will not be necessary.

The possibility that this meter could act to initiate control devices is obvious. Production of natural gas can be controlled automatically. The advantages of mass metering for control initiation in process work could easily constitute a separate paper.

Note that in case of failure of any component of the meter the flow is unrestricted. There are many applications in which this is a requirement.

The pressure drop across the meter is very small.

For many years investigators have attempted to devise flowmeters that will give a correct reading for pulsating flow. There are none entirely acceptable to the industry at the present time. Designers of flow devices that are intended to average pulsating flow invariably base their conclusions upon theoretical simplified wave forms which are symmetrical in nature. Unfortunately, the wave forms in pipelines are extremely complex in nature; they are non-symmetrical and they usually have a high frequency component. It appears that the mass meter discussed here will have excellent characteristics for accurately metering pulsing flows. Actual response characteristics cannot be accurately predicted, however, until a thorough test program has been completed.

Conclusions

The desirability of metering and selling natural gas on the mass principle is apparent. The advent of a satisfactory mass flowmeter will result in:

1. Greatly improved accuracy in the metering of natural gas.
2. Large economic savings resulting from decreased calculation time as well as increased accuracy in gas accounting.

The mass flowmeter discussed here should provide a practical and economical solution to the problems of properly designing, manufacturing, calibrating, marketing, and servicing a simple, rugged, highly accurate flowmeter for natural gas.

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Part 1: Selecting a Crossing Site

Engineering Underwater River Crossings

Leo M. Odom,
Pyburn and Odom, Consulting Engineers,
Baton Rouge, Louisiana

Basically, the engineering of submarine crossings of unstable rivers is this simple: Determine what forces will act on the line during its construction and operation, and either eliminate or counter these forces using the most economical means possible.

Although this statement is absolutely true, it is something of an oversimplification. What forces will act on the line? Will the banks cave? Will the river scour beneath the pipe? In the latter case, what is the impact load of the current? What about vibratory loading?

The answer to these and other cogent questions comes only after study of the entire river system with emphasis on the immediate section through which the pipeline will be laid.

A river is individual, and very few general statements can be made that would be applicable to all rivers. Each river must, therefore, be considered as a separate problem. Some have rocky beds; some are subject to sudden and severe floods; some meander in silty plains, and some have acid or alkaline water. Depths may vary from 2 to 3 ft to 200 ft. Widths may vary from 200 or 300 ft to more than a mile.

A study of the hydrology is necessary for the determination of rainfall, runoff, and stream flow. The geology of the

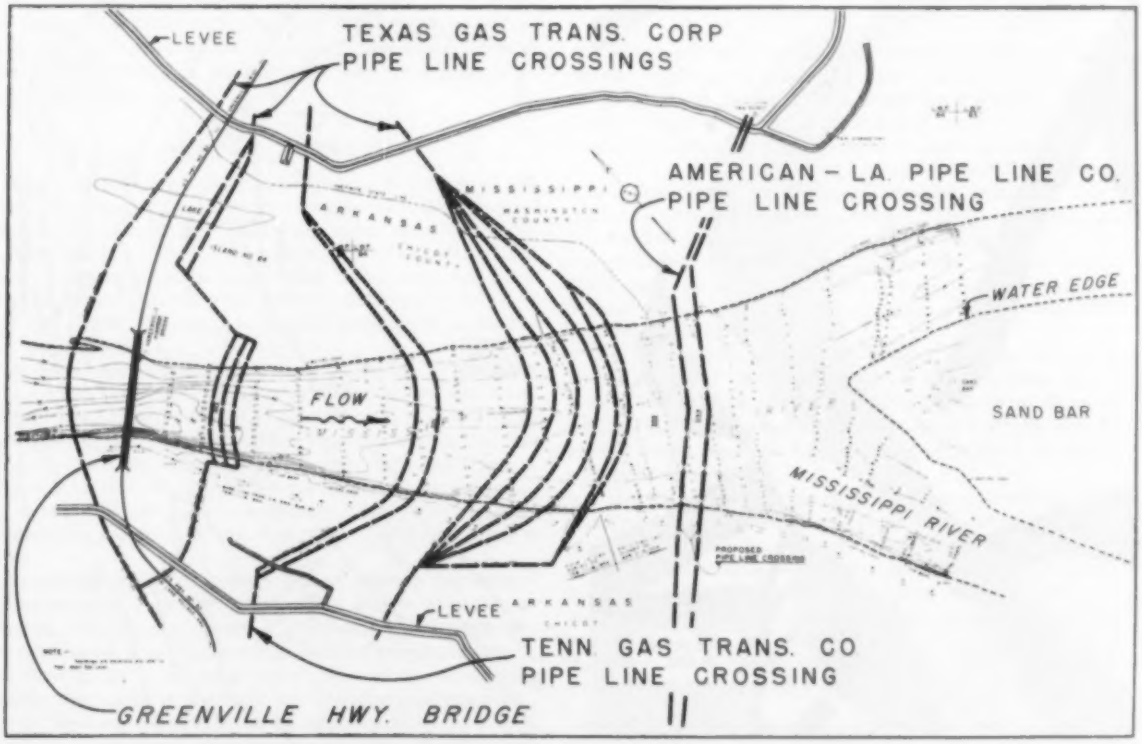


FIG. 1. Pipeline alley near Greenville, Mississippi, has 14 underwater crossings. Note that there are conflicting opinions as to the best method of laying the crossing. Some bow upstream, some bow downstream, and some go straight across.

watershed and of the river reveals significant data concerning erosion and future action. Hydraulics, soil mechanics, and potamology (the science of rivers), are important fields of investigation in the solution of river problems. Of most use in the understanding of present regimen and the prediction of the future river activity are the gage records and maps of previous, as well as up-to-date, surveys and previous and up-to-date cross-sections and profiles for considerable distances up and downstream from the site under consideration.

TYPES OF CROSSINGS

Aerial. There are basically two types of crossings; viz., bridges and underwater crossings. A great deal of study has been devoted to the design of bridges for pipelines so as to minimize the size of members and the cost of the piers. Nevertheless, they are generally more expensive and more costly to maintain than properly built underwater lines. Too, they are liable to damage from high winds as well as flying objects. They also are as vulnerable to damage from caving banks as underwater lines. Their economical use is generally confined to deep gorges with stable banks.

Submarine. In the construction of underwater crossings several ideas about the proper layout have been followed. Crossings are sometimes made by laying lines across the river on top of the bed and banks, but more frequently by entrenching them into the bed and banks to give them protection. When lines are laid on the bottom without entrenchment, they are usually heavily weighted and the crossing is made by using a number of small lines, which are connected to the land line through headers.

Formerly, it was commonly accepted practice to lay all lines with bows either upstream or downstream between banks. Lines laid in this manner were sometimes placed in trenches and sometimes on the bottom without entrenchment. One company has used multiple small pipe laid in "sinusoidal" curves across the bottom of the Mississippi River at its crossings of that stream.

The advantages claimed for curves in the plan of the crossing seem to be questionable, but there is no doubt as to the following advantages:

1. Greater flexibility of small pipe in conforming to bed changes, provided extra length is available.
2. A number of smaller lines in a crossing make complete loss of service by rupture of the pipe less likely.
3. A cheaper crossing can be constructed without entrenchment.

EARLY SMALL-LINE CROSSINGS OF MISSISSIPPI

The crossing of the Mississippi River near Natchez by Interstate Natural Gas Corporation with seven 10-in. lines was completed in 1926, and to date, only one line has been lost. It was broken by the dragging anchor of an LST in 1944.

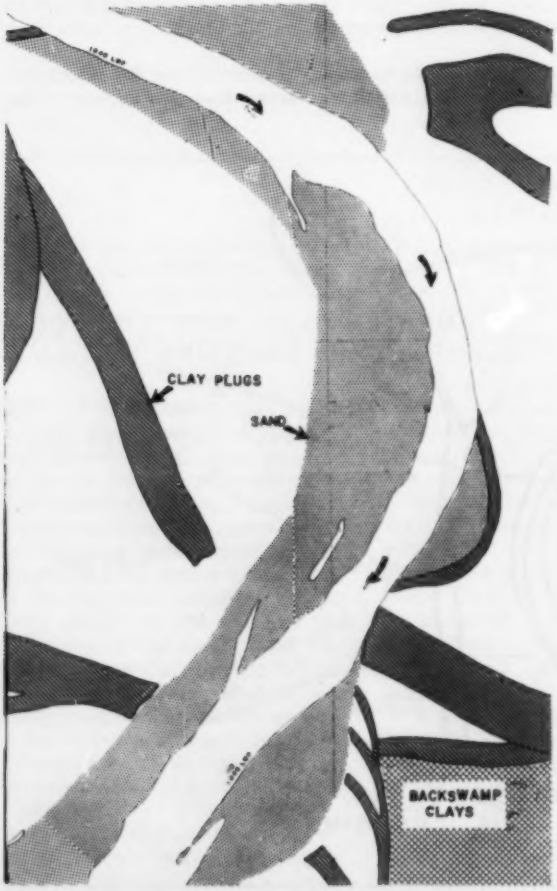


FIG. 2. Site of typical Mississippi River crossing used in the accompanying text. The alluvial deposits shown here affect the future course of the river through this section. Clay plugs have deposited in ox-bow lakes formed when the river made cut-offs.

FIG. 3. Where to cross the river? Shown here are two sites. Both look good. Yet one is a considerably better bet than the other.

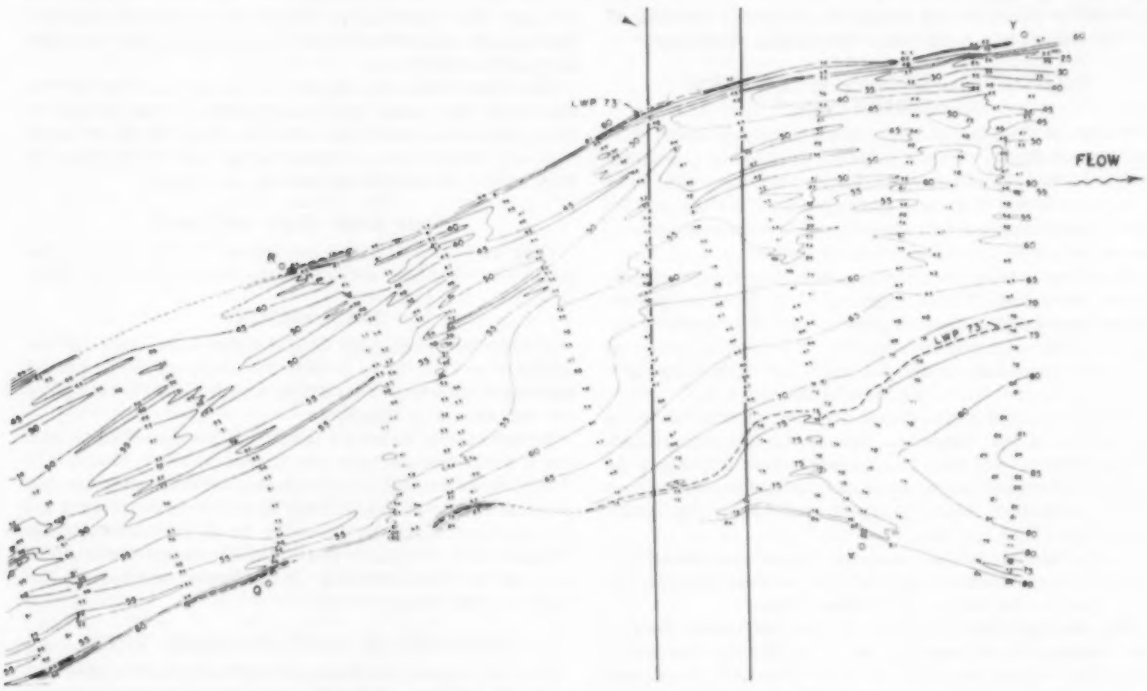


FIG. 4. Hydrographic survey of the area of proposed site No. 2, which the author selected as the better of the two crossing sites.

These lines are very heavily weighted. The river at this location is considered unusually stable; nevertheless, it has been found necessary to keep a constant watch on the crossing and to "feed" a good many feet of pipe into the river on each line from time to time to prevent breaks due to bed and bank changes even though they have been comparatively small.

PRACTICE TODAY

The crossing of a river by straight continuation of the land line pipe without decrease in size provides obvious advantages although it is usually somewhat more expensive in first cost. In a river of the type and size of the Mississippi such a crossing must be entrenched below probable scour lines in the bed and into the banks a sufficient distance to provide against exposure by caving during the economic life of the project.

In large important crossings an auxiliary line of the same size as the mainline is always provided as an insurance factor. One of the main advantages of using pipe of mainline size in the crossing is that scrapers can be carried through the lines without the necessity of having traps at each side of the crossing. When the design of such a crossing is based on adequate investigation and careful consideration of the factors involved, it is fully as safe as any other type.

In making all river crossings it is of primary importance to locate them in a part of the river that is as stable as possible. The Mississippi River is notable for its meandering tendencies, and stable reaches are the exception. One of the most stable is found in the vicinity of the Greenville Bridge. This reach of the river has therefore become a veritable "pipeline alley," as can be appreciated from Fig. 1. Here, there are lines laid straight across the river as well as lines bowed both up and downstream. Tennessee Gas Transmission Company has several lines on the bridge itself. This company felt it would be cheaper to buy the existing toll highway bridge and make it free to highway traffic than to build a new bridge for pipelines only.

SELECTING A SITE

Rivers not only differ among themselves, but the characteristics of the same river vary greatly from place to place along its length. Although it is conceivably possible to construct a durable river crossing at any given location, from a practical standpoint it is necessary to exercise great care in the selection of the site for the crossing in order to be able to build it within the limits of available time and for a reasonable amount of money. Overall alignment of the pipeline must be taken into consideration in the selection of the site of course, but when rivers the size and character of the Mississippi are to be crossed, major changes in alignment frequently are necessary in order to avoid reaches that exhibit extreme instability.

The basic problem in the selection of the site, as well as in the design of the crossing of an alluvial river, lies in understanding what the river is in the process of doing at the time and by study of this action and of available data to predict within relatively narrow limits what it will do within a given future period.

Basic data necessary to compiling the history, geology, and hydrology of the stretch of river within which the crossing could be made feasibly and economically usually is obtainable from records of the Corps of Engineers, U. S. Army, and other federal and state agencies. A study of this information makes possible a fairly close approximation of the best location. The next step is to make an accurate survey of the river, noting caving banks, sand bars, etc., in order to arrive at exactly the best location within the selected reach.

TYPICAL EXAMPLE: STUDIES TO SELECT A CROSSING SITE

To illustrate the factors that must be weighed before selecting a crossing site, let's run through briefly the studies

required for selection and design of a proposed crossing of the Mississippi, at a point below Greenville, Mississippi.

GEOLOGICAL SETTING IS THE FIRST CONSIDERATION

The lower Mississippi River flows through a valley that was formed during the last cycle of world-wide glaciation. In this valley the deposits of Recent alluvium were laid down in trenches that were excavated by the river and its tributaries during the last glacial stage when sea level was several hundred feet lower than at present.

On either side of the entrenched valley abrupt escarpments composed of older geological formations project above the present Alluvial Valley surface. The material between these escarpments consists of Recent alluvium of varying composition, grading toward finer soils irregularly upward from basal coarse graveliferous deposits.

The lower basal graveliferous deposits were laid down as the sea level first began its rise as the glaciers melted. Stream slopes were then much steeper than at present. As sea level continued to rise and alluviation of the entrenched valley proceeded, stream slopes decreased and the gravel gave way to finer deposits.

In the latitude of our proposed pipeline crossing, the valley is some 80 miles wide, and the course of the river lies very close to the center of the flood plain.

The deepest portion of the entrenched valley floor in the vicinity of the crossing lies at an elevation of about 100 ft below mean sea level, some 200 ft beneath the present surface. The top of the basal graveliferous deposits in the area of the crossing ranges in elevation from plus 10 to plus 70 ft msl (mean sea level), and has an average thickness on the order of 60 to 80 ft. These deposits are overlain by finer sands, silts and clays. The depths attained by the modern river in the vicinity of the crossing are such that the basal graveliferous deposits are being extensively reworked. Fisk cites borings near Lake Providence indicating that at some locations the entrenched valley floor, i.e., the surface of the Pleistocene trench, has been swept clean and even further entrenched by the modern river and basal graveliferous deposits have been washed out and are now replaced by finer materials. The entrenchment of graveliferous strata leads to the deposition of relatively coarse materials in modern river features.

EFFECT OF GEOLOGICAL SETTING

What is the effect of this geological setting on the proposed river crossing? For one thing, the river channel migrates and its course is sinuous. Only a few reaches (straight runs) have developed. The river tends to meander most rapidly where it cuts across deposits of older meander belts and alluvial fans.

Generally, migration in this section of the river is controlled by clay plugs that were formed in the process of filling ends of ox-bow lakes resulting from cutoffs of necks or loops. Revetments constructed by the U. S. Corps of Engineers also control the reaches and bends.

SAND AND CLAY DEPOSITS

Clay and sand deposits are shown on Fig. 2. Note the relation of sand bars and islands to the course of the river.

AREA HISTORY

A detailed comparison of low water bank lines for the period from 1881-82 to 1949 in the area considered for the crossing is shown on Fig. 4. The crossing sites investigated are also shown on this figure.

It may readily be seen from Fig. 3 that the meander pattern is quite irregular in this portion of the river. This results chiefly from the stabilizing influence of the numerous clay plugs, as shown on Fig. 2. They have served to prevent the development of regular meander bends in historical time. Irregularity is also partly due to the development of cutoffs, both natural and artificial, in the upper sections of this portion of the river.

ANALYSIS OF TWO CROSSING SITES

For our crossing we have selected two possible sites that seemingly offer good stability, and have relatively narrow bank-to-bank spans. Crossing site No. 1 looks excellent at first glance. This reach is confined to a certain extent by clay plugs, however, the channel at present lies almost entirely within a sand bed. The sand deposits on each side of the channel separate it from the plugs by hundreds of yards. The bank lines shown for the various years illustrate the wide belt within which the river can be expected to wander within the "confined" area.

Control. Though the plugs undoubtedly will largely control future movement, the control exerted in this area is largely relative. It will serve to prevent the development of long, regular, extended bends, but will not prevent variation in bank line locations, which would be too great to be provided for by a crossing design. It should also be noted that bed changes within a reach such as this one will occur with great rapidity even though the bank lines remain relatively stable.

The rapidity of changes that may be expected in such a reach, together with the relative magnitude of what, to the

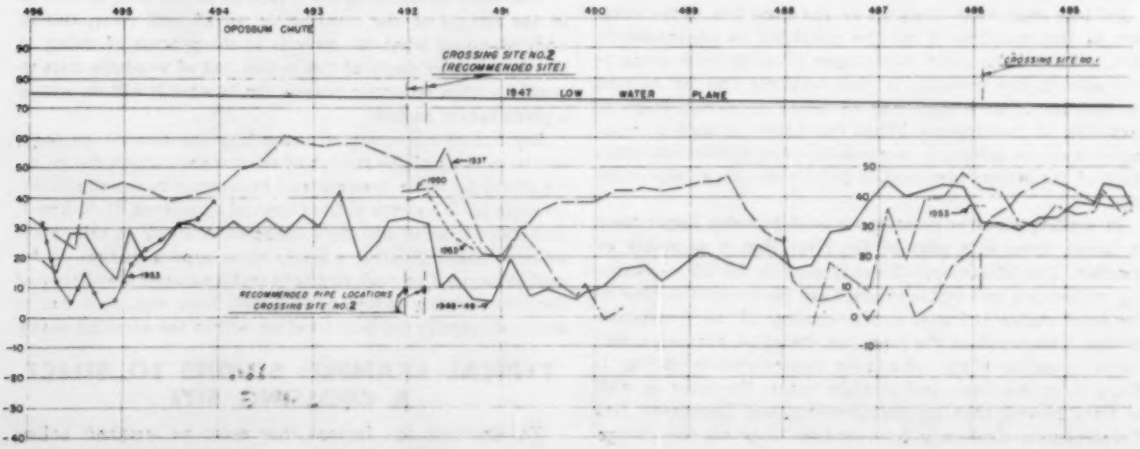

OPOSSUM CHUTE
CROSSING SITE NO.2 (RECOMMENDED SITE)
1947 LOW WATER PLANE
CROSSING SITE NO.1
RECOMMENDED PIPE LOCATIONS CROSSING SITE NO.2

FIG. 5. Comparison of thalweg depths at the two areas.

river, are minor and temporary bank line changes, may be illustrated by reference to Fig. 3. The erosion that resulted in the high left bank location shown at Cross Site No. 1 occurred during the high water of 1942. During this high water period, with deep water against this bank and rapid erosion in progress, the Corps of Engineers made two levee setbacks, only one of which proved to be actually needed. Soon after the set-backs were made the location of the caving shifted and the pocket core that had formed was filled by a sand bar.

This bank recession resulted largely from the angle of attack by the channel across the present Mayersville Bend bar as it existed during the 1942 high water. By the time this had occurred, any pipeline crossing at this location would have been destroyed with little hope of immediate repair.

Incipient chute. There is at present an evident tendency for the development of a chute across the bar of Mayersville Bend. This "incipient chute" (revealed by aerial photos of December 1952) follows closely the right high bank behind the bar in the upper portion of the bend and is thus directly aligned with the bar on the left bank between Mile 383 and Mile 487.

The possible adoption of the chute behind the Mayersville Bend Bar by the river as its main channel is believed to be sufficient reason for recommending against Crossing Site No. 1. Once the chute should be adopted, caving of the left bank would be extremely rapid, and repair of the line at this location during high stages would be extremely hazardous, if not impossible.

ANALYSIS OF SITE NO. 2

It is preferable, of course, to locate a pipeline crossing in a relatively straight segment of the river where little or no change in alignment is anticipated. The absence of such segment in the vicinity within which a crossing must be made, however, sometimes requires the location of the pipeline crossing in a bend where the river is presently caving. At such locations future movement often may be predicted with a considerable degree of confidence, and the necessary allowances can be made for future bank movement.

Historical study. Historically, the bank line variations at Crossing Site No. 2 compare favorably with those that have occurred at other locations in the region considered. The right bank has remained virtually unchanged during the entire period covered by the bank line comparisons shown on Fig. 3. Changes in the location of the left bank have fluctuated rather narrowly about a "mean" bank line. Changes in the left bank location at the point of the crossing have been of minor importance in comparison with the changes immediately upstream and downstream.

Crossing Site No. 2 is located at the upstream end of a long, sweeping bend to the right, which developed since the adoption of Opossum Chute as the major river channel. This occurred about 1940 following a cut-off. The greatest movement in this bend has occurred at about Mile 489.2, where approximately 4000 ft of the left bank was lost between 1937 and 1948. Since 1948, extensive revetting in this bend largely has arrested its outward migration.

The bend below this site may be regarded as largely stabilized at its present location, subject to the possibility of the development of a chute cut-off. Further development of the presently occupied main channel probably will take the somewhat unusual form of an upstream movement of the point of caving until stabilized by revetment construction, or until an alignment is attained that will cause cessation of caving. The present alignment of Opossum Chute is such that a current directive that would result in extensive caving at Crossing Site No. 2 is not probable, although there will be a certain amount of caving along the left bank at this location.

More critical conditions exist upstream from the site at the head of Opossum Chute. As may be seen from Fig. 3, there has been extensive caving at the lower end of Sarah Island Cut-off, particularly since 1949. The rapid movement of this bend into the sandy deposits forming Sarah Island has been arrested by impingement of the lower end of this bend against the clay plugs surrounding Pittman Island at Opossum Point. Growth of the left bank bar, which initiates this bend, has been maintained below the point of the "hook." There is an evident tendency for the "upstream movement" of the right bank bar at the lower end of Opossum Chute, resulting undoubtedly from the extensive caving along the right bank at the lower end of Sarah Cut-off.

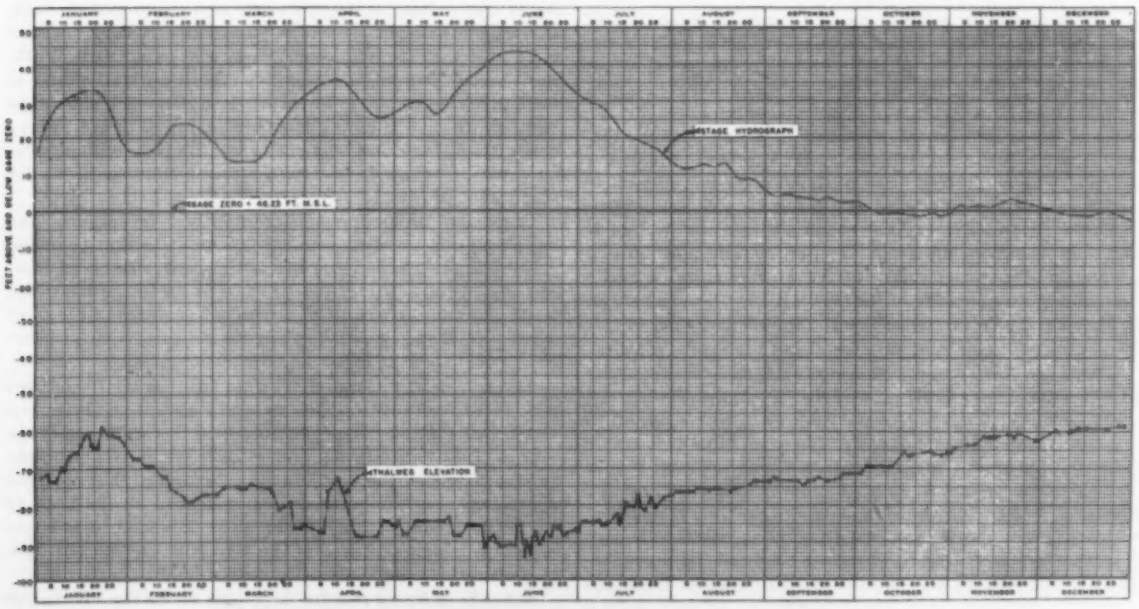


FIG. 6. River stage and bottom variations at the Vicksburg discharge range.

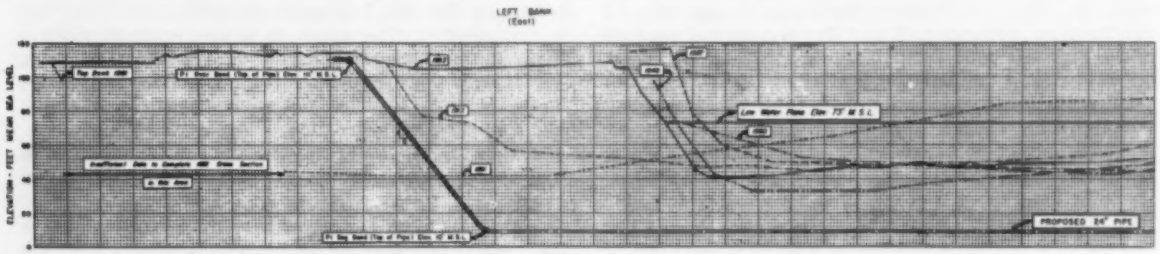


FIG. 7. Proposed profile of one of the crossings. The author selected depth well below any known scouring.

Revetment of the caving bank at the lower end of Sarah Island is scheduled by the Mississippi River Commission for construction, and resulting stabilization of this bend will result in stabilizing the existing right bank bar at the lower end of Opossum Chute. Elimination of the large and continuous supply of sand to the right bank bar at the crossing site probably will result in stopping the unusual upstream growth of the bar, and permit more normal attrition of the upper end of the bar, with its accompanying downstream "movement." Conditions in Sarah Island Cut-off will be ideal for the development of a chute type cut-off, which is quite possible even without revetment construction. Occurrence of a chute type cut-off in Sarah Island bend definitely would enhance the desirability of Crossing Site No. 2.

Stabilization of Sarah Island Bend by revetment construction should, through retardance of the right bank bar growth at the lower end of Opossum Chute, alleviate the present attack on the left bank near the upper end of Mayersville Bend. Further, it shoud prevent additional upstream movement of the point of left bank caving toward Crossing Site No. 2.

A comparison of thalweg* depths revealed by recent surveys in the area shown on Fig. 4 is presented on Fig. 5. Crossing Site No. 2 is seen to be located at the extreme upper end of the bendway deep, near the point of transition from the crossing bar to the bend.

For these reasons our best choice is apparently Crossing Site No. 2.

ENTRENCHMENT

Entrenchment in alluvial rivers requires a great deal of consideration. Bank and bed changes are constantly occurring in such streams to some extent. In order to insure an underwater pipeline against damage from currents, dragging anchors, corrosion, etc., the pipe must be entrenched into the bed and banks sufficiently that bank movement will not disturb it nor scour uncover it during the economic life of the projects. The accomplishment of this objective may be limited in some cases by the availability of capable equipment.

The decision as to the entrenchment into the bottom is based on a study of the available cross-sections and thalweg profiles, and a consideration of the phenomenon of cyclic variation in the elevation of the bed, which varies with stage. In the most stable reaches of an alluvial river neglect of this last factor has been known to result in failure of a pipeline.

There are few locations where the amount of this variation has been measured accurately. A graph showing the variation in the elevation of the thalweg during a period of one year plotted against gage heights at an otherwise stable cross-section on the Mississippi River, is shown on Fig. 6. The decision as to the amount of entrenchment into the banks, as well as the decision as to the maximum depth at which to place the pipe in the channel, is based to a considerable extent on the comparative study of the cross-sections at the site for the various years of record. Bank entrenchment must also be based on a study of past changes in the horizontal pattern of the river. A reach that is stable today may be found to be in imminent danger of becoming unstable because of changes that are occurring above or below the site.

There are very few places on the Mississippi above Baton Rouge where bank changes cannot be expected to occur more or less rapidly. The decision as to amount of bank entrenchment must be based on an estimate of what the rate of change will be in the future and how long the project is expected to last.

The best method for entrenching the pipe across a large alluvial stream is by means of hydraulic dredging in the bed and in the banks up to the water surface, the trench to be excavated prior to the placing of the pipe. Usually, it is not necessary to fill the trenches between banks because the river will take care of that in short order. Bank trenches should be backfilled to restore the original alignment of the bank line if it is practicable to do so. This backfill should be protected by riprap or sandbags and the top of bank shaped so as not to permit drainage to run over the new fill.

PIPE

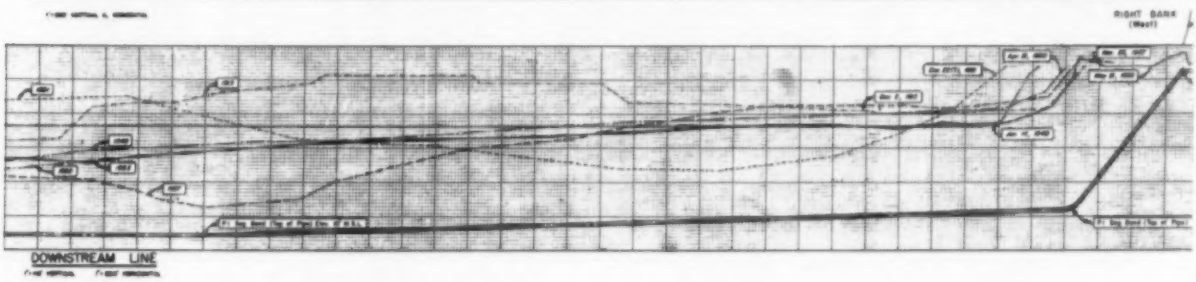
Steel from which the underwater pipeline is made should have as much flexibility as is consistent with strength and weldability requirements. For land lines it has become the practice to raise the yield point by expansion of the pipe in order to lower the required wall thickness. Underwater crossings are more inaccessible and a break in such a crossing is many times as expensive to repair as a line on land. It is very important, therefore, to specify carefully the steel to be used with regard to ductility as well as strength. Working stresses should be lower than those normally used in land pipe. Sagbends and overbends, if required, should be bent on the job to fit the trench as actually dug. In many cases it will be found feasible to lay the pipe without prebent bends, which is of considerable advantage from the standpoint of laying.

Corrosion protection is accomplished by doping and wrapping and cathodic protection similar to that provided on land lines. It is necessary to exercise extreme care in corrosion control of a crossing because of its future inaccessibility. A careful check of the chemical qualities of the river water at all stages should be made to determine whether any special precautions will be necessary.

In the design of large steel pipelines the wall thickness required to take care of the pressure always provides less weight than that necessary to overcome the buoyancy of the empty pipe. This buoyancy must be overcome by the addition of weight to the line. Weight in excess of that required for overcoming the buoyancy as computed on the basis of its displacement of fresh water must be added in order to cause the pipe to settle into the trench at the desired location even if it is partially filled with soft silt.

It has been found that for large pipe across the Mississippi River the addition of weight to give a total weight in air

*A line following the lowest part of a valley, whether under water or not — Webster's International Dictionary.



equivalent to about 1.3 times that of the volume of water displaced by the pipe, plus the weighting material, is sufficient for good placing and will insure that the pipe will remain in place until the trench is backfilled. Small pipes frequently are laid directly on the bottom without trenching because of the relative expense involved. Such lines usually are weighted very heavily in order to resist movement due to currents.

Weighting can be accomplished by increasing the thickness of the pipe; by the attachment of concrete or steel weights (called clamps); or by continuous coatings.

The requirement for retention of maximum flexibility should be considered in the choice of a weighting method and material. It is also important, particularly during the laying process, that the area and length of pipe exposed to the current be as small and as smooth as possible. Each method of weighting still has its advocates but the continuous coating, using heavy-aggregate concrete for the coating material, is now the most commonly used. Barite aggregate has been found to provide a strong, durable concrete weighing consistently 185-190 lb per cu ft. Coating methods are such that the surface is left relatively smooth and the coating adheres to the pipe quite tenaciously, serving to protect the corrosion coating during handling.

Fig. 8 shows design profiles for the main and auxiliary crossings of a 30-in. pipeline across the Atchafalaya River. The profile is well below the bottom elevations of the cross-sections made from all surveys that could be obtained. The sagbend radii are such as to permit laying of the pipeline without stressing it in excess of 20,000 lb per sq in. in a longitudinal direction. Overbends were made cold and coated on the job. Pipe used was 0.656 wall thickness and coating consisted of 2½ in. thickness of 190-lb concrete with wire mesh reinforcement.

CONSTRUCTION

Pipeline river crossings usually are placed either by pulling the pipe across the river after it has been welded-up on shore, or by placing it from a laying barge. The laying barge method is usually slower but is preferred on large rivers, particularly where there is considerable current. Whether the pipe is placed by use of a laying barge or is pulled, it must be supported during the installation process to prevent excessive longitudinal stresses from developing.

In order to get a good installation of a pipe across a large river, it is necessary that the contractor be experienced on river work and that he have adequate and proper equipment.

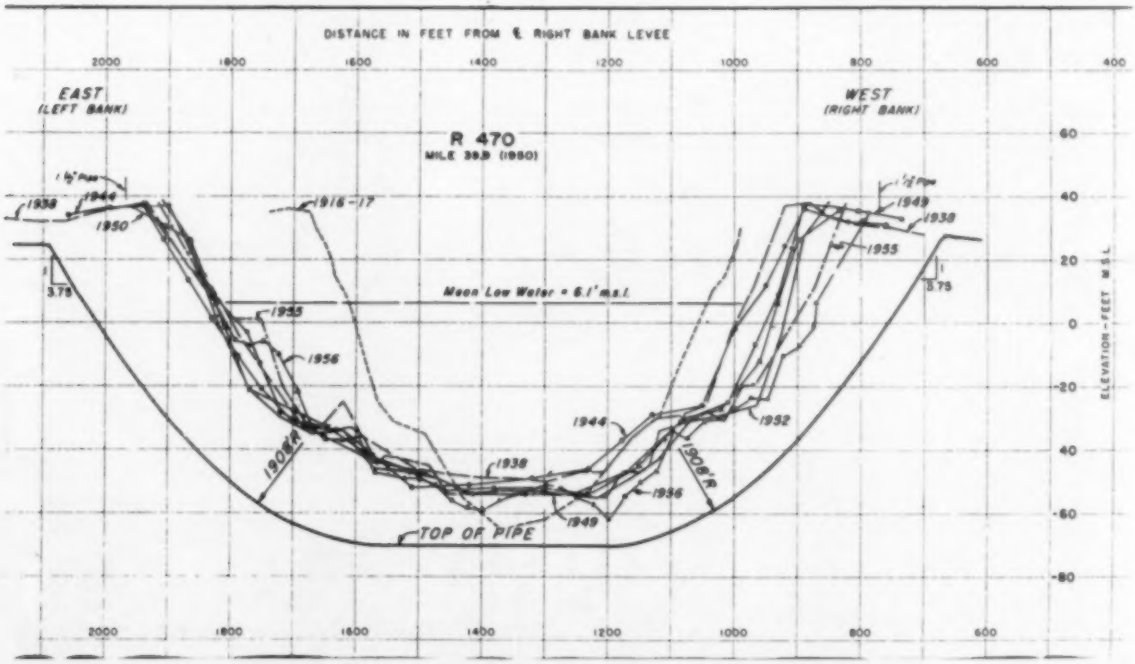


FIG. 8. Design profile of Atchafalaya River crossing. Note that the 30-in. pipe was laid with no fabricated bends below the surface of the water.

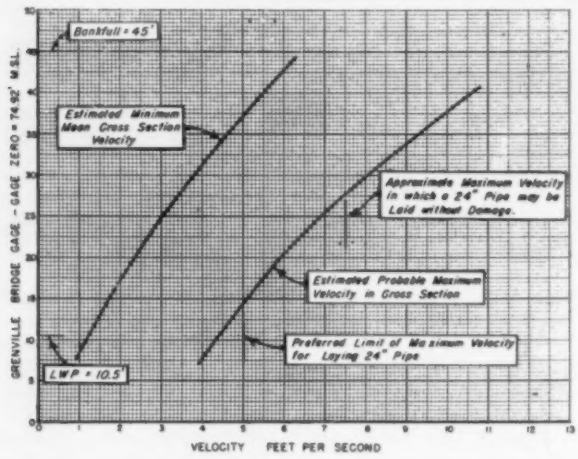

Bankfull = 45'
Estimated Minimum Mean Cross Section Velocity
Approximate Maximum Velocity in which a 24" Pipe may be Laid without Damage.
Estimated Probable Maximum Velocity in Cross Section
Preferred Limit of Maximum Velocity for Laying 24" Pipe
LWP = 10.5'
GRENVILLE BRIDGE GAGE - GAGE ZERO = 74.92' M.S.L.
VELOCITY FEET PER SECOND

FIG. 9. Estimated stage-velocity relationships on Mississippi near Greenville bridge. These curves are approximate; no allowance was made for direct effect of contraction at the bridge.

Construction contracts usually are let to the low bidder on a lump sum basis. Specifications are framed to ensure against damage to pipe during construction and to provide that a good bed and backfill are provided. The actual details of construction are left to the contractor. This practice has resulted in permitting the owners to take full advantage of the ingenuity of contractors in devising more economical methods of construction.

SELECTION OF WORKING SEASON

On all rivers there are certain months in the year during which it is feasible to work and others when the best efforts are likely to fail. There are very few rivers for which it can be guaranteed that a trench can be opened up and a pipe can be laid every year. Some years, unpredictable flash floods will occur and halt dredging, fill trenches, or break the pipe while it is being laid. On the other hand, a great deal of misery can be avoided by the study of the hydrographs of the river for a number of years and the selection of that period of the year during which the chances of successful work are the best.

The critical point in dredging of trenches is reached when the velocity becomes such that it begins to move the bed load of the stream. This point usually can be determined rather closely. Velocities in the Lower Mississippi River bear a close relationship to gage heights. A graph showing the relationship between velocities and gage heights near Greenville is shown on Fig. 9. A graph prepared for a site on the Mississippi River on the basis of recorded gage heights for a number of years, from which the gage heights to be expected during the various months of an average year can be computed, is shown on Fig. 10. A horizontal line is drawn on the chart at the gage height at which the velocity would be sufficient to cause the pipe to flutter during the laying process.

INSPECTION AND TESTING

The best laid plans of engineers are worthless unless they are followed out. The only way to ensure compliance with specifications is to inspect the work carefully during construction and to test it when it is completed. The construction of a dependable river crossing requires that the welding and corrosion inspection should be of a very high order. It is also necessary to inspect carefully dredging of the trench to proper grade and alignment. The pipe laying operation shoud be checked continually during the progress of the work.

In the surveying and inspection work of construction of trenches and keeping up with the location of the pipe while it is being laid, the author's firm has found the use of an electronic sounding device to be indispensable.

Pressure testing of the underwater line is usually more rigid than for land lines. The usual practice is to test the joints separately at pressures in excess of working pressure before welding them into the line. After the line is laid, it is customary to run a pig through and to give the crossing a test for several hours at a minimum of 125 percent of working pressure before backfilling. The testing is done either with gas, air, or water.

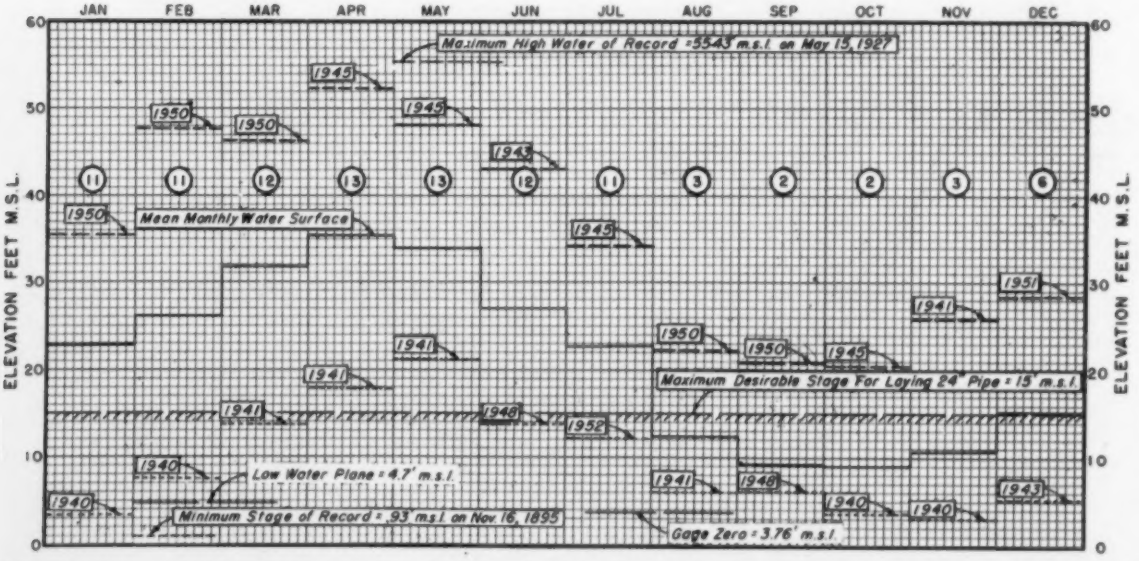


FIG. 10. How to select working season. Shown here is mean monthly water surface elevations between 1940 and 1952 at the Bayou Sara Gage on Mississippi River. The maximums and minimums for the years are shown too. The numbers in circles show the number of months in this period with mean monthly stages above 15-ft MSL (mean sea level).

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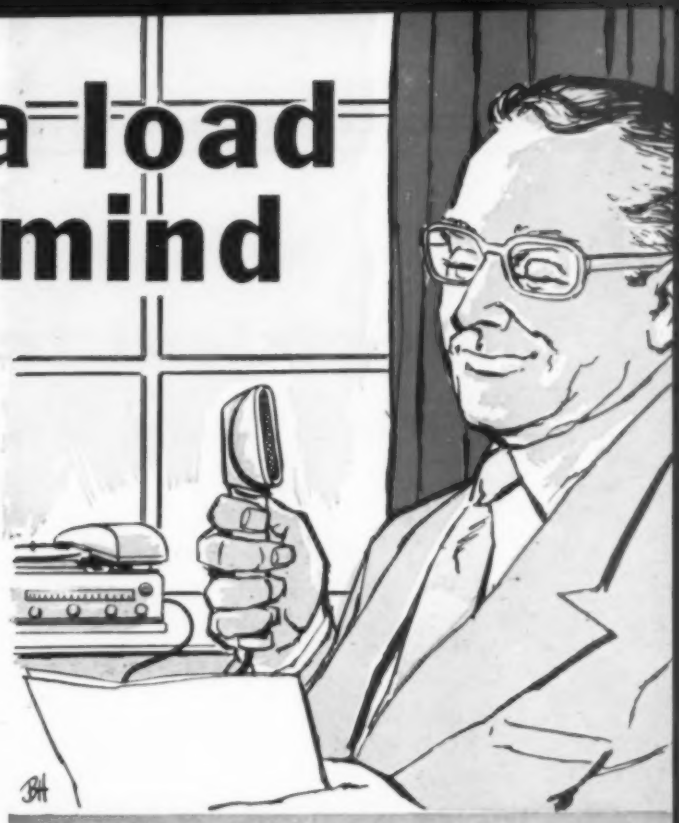

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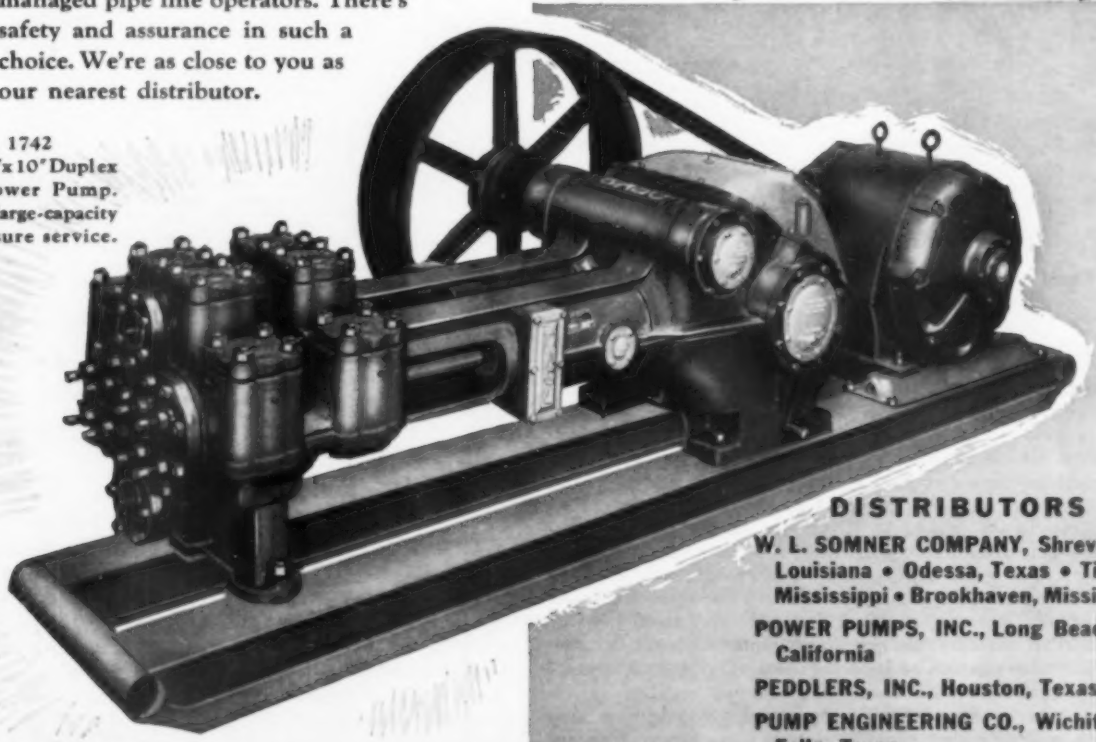

Fig. 1742
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Management, especially those who are responsible for profits and the general economics of their businesses are vitally interested in how to reduce operating costs.

A good protective system, properly installed not only will extend the life expectancy of the capital investment, but will reduce investment costs of a complementary protection, fixed charges, and operating and maintenance costs.

Costs in the last 15 to 20 years have increased tremendously, up from approximately $1500 per mile per inch of diameter to better than six times that amount. Not too long ago it was considered good enough if a line lasted 20 years. Generally, the opinion now is that it should last 40 years or better. Of necessity, life expectancy must be greater, because present-day methods of financing demand low operating costs and minimum maintenance.

Top performance requires the use of adequate protection with materials that provide *electrical insulation,* that are impervious to moisture penetration, and are immune to soil chemicals or bacterial action of the soils, and will maintain a permanent high electrical resistivity. Cathodic protection then can be considered as an economical complementary protection, and assure a reasonable life expectancy.

Long before the cause of corrosion was found to be electrochemical both the producer and consumer industries were demanding materials that were water-proof. Experience indicated that some non coal-tar base materials were becoming

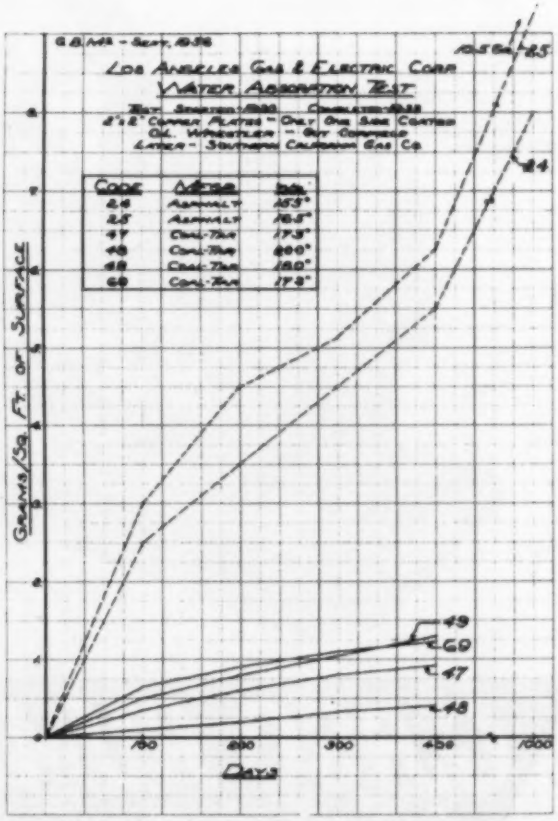
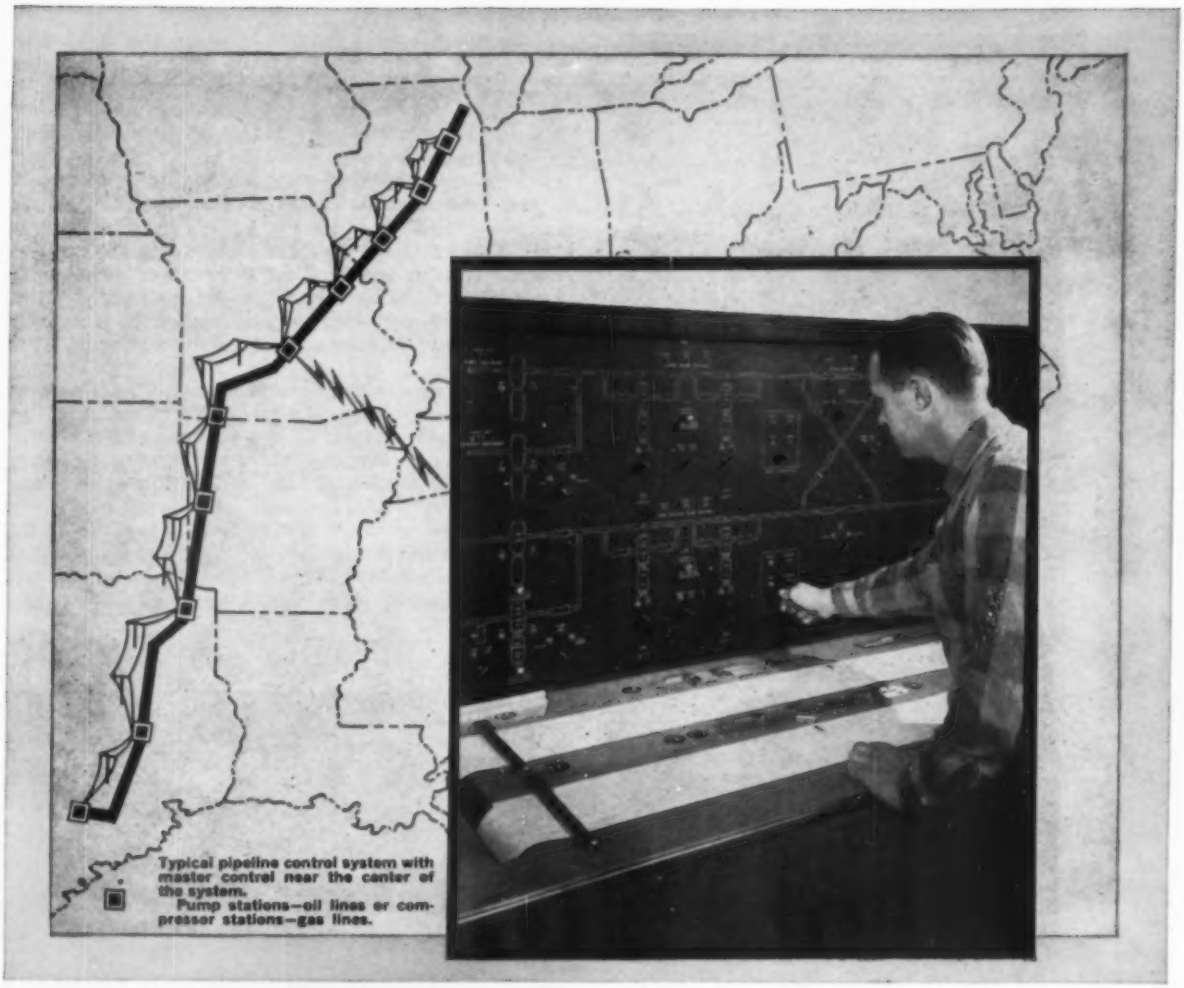


FIG. 1. Results of first tests made to evaluate relative resistance to water absorption of coal-tar enamels and non coal-tar products.



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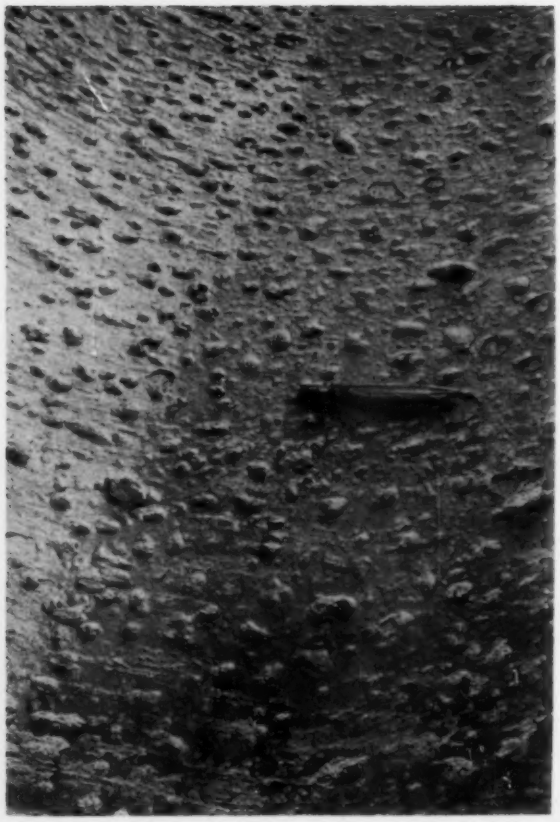

FIG. 2. Asphalt coating on inside of water pipe after six years' service, showing blisters and tubercles on surface.[2]

water-logged, allowing corrosion to occur underneath the coating and in most cases allowing the coating to slough off. These failures usually occurred within a period of 5 to 10 years. Thus in the late 20's and early 30's there were many tests devised to determine which coatings had the lowest moisture penetration. Some of the tests will be described and results given. (Additional data will be contained in Part 2 of this series.)

Water Absorption Tests

As far as we can determine the first tests set up to evaluate the relative resistance to water absorption of coal-tar enamels and non coal-tar products used for underground pipe coatings was conducted by O. L. Wrestler, under the supervision of Guy Corfield, for the Los Angeles Gas and Electric Company about 1930. The tests are described as fol!ows:

"The following is an attempt to devise laboratory methods for testing water and electrical resistance, so that the tests can be made under the same conditions, in any location, and so be entirely comparative in nature where no acceleration is used, merely water immersion with periodic tests.

"Three thin copper plates, 2 in. square are coated with the protective materials so that after drying to a constant weight they will have a thickness of ⅛ in. (this thickness does not include the copper plates).

"Hot applications are heated to temperatures of free flow, being careful not to overheat.

"The net weight of the coating on the plates is determined. Then they are immersed in distilled water, from which they are periodically removed, the surface water dried off and their increase in weight determined. This represents the amount of water absorbed.

"The surface water is removed by drying exactly 15 minutes in a calcium chloride desiccator. Fifteen minutes is the time required for the rate of drying to become constant, which means that the surface water has been removed. We are certain all surface moisture is removed. Drying a few minutes too long introduces error.

"All absorption tests are made in duplicate. In every case the results check almost exactly. The result of some of the materials tested are shown in Fig. 1."[1]

Another of the early tests was originated by the Los Angeles Department of Water and Power, after an intensive investigation of coal-tar enamel in varied applications, which included centrifugally spun and hand applied lining in water pipes and penstocks, hand applied in water tanks, and many others.

One of the investigations was of enamel in a penstock of Pacific Gas and Electric Company, San Francisco. This enamel was applied in 1913 and was examined in 1939.

"There was not a rust spot or blister to be found, and when the scum was washed off, the surface looked like new enamel.

"The longest record of coal-tar enamel available to the writer was its reported use applied to steel plates of a dry-dock when built in 1892 at North Shields, England, and was in continuous service until dismantled in 1938.

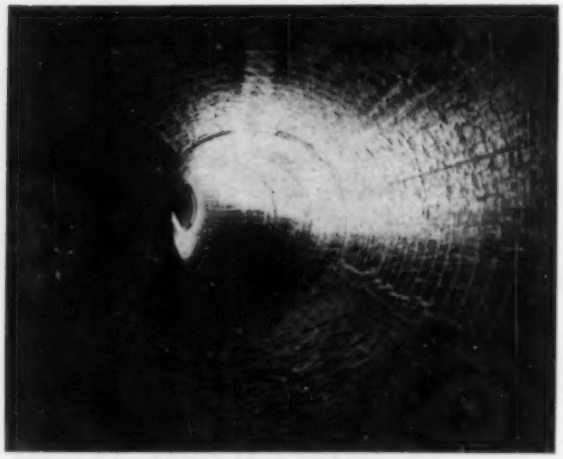

FIG. 3. Coal-tar enamel on interior of Boquet Canyon Pipeline (Los Angeles Department of Water and Power) after six years' service, showing unblemished condition except for apparent roughness from brush marks caused by hand application.[2]

FIG. 4. Asphalt-coated pipe after six years underground in sand backfill, showing streak down the side where water ran out of a broken water blister as photo was taken.[2]

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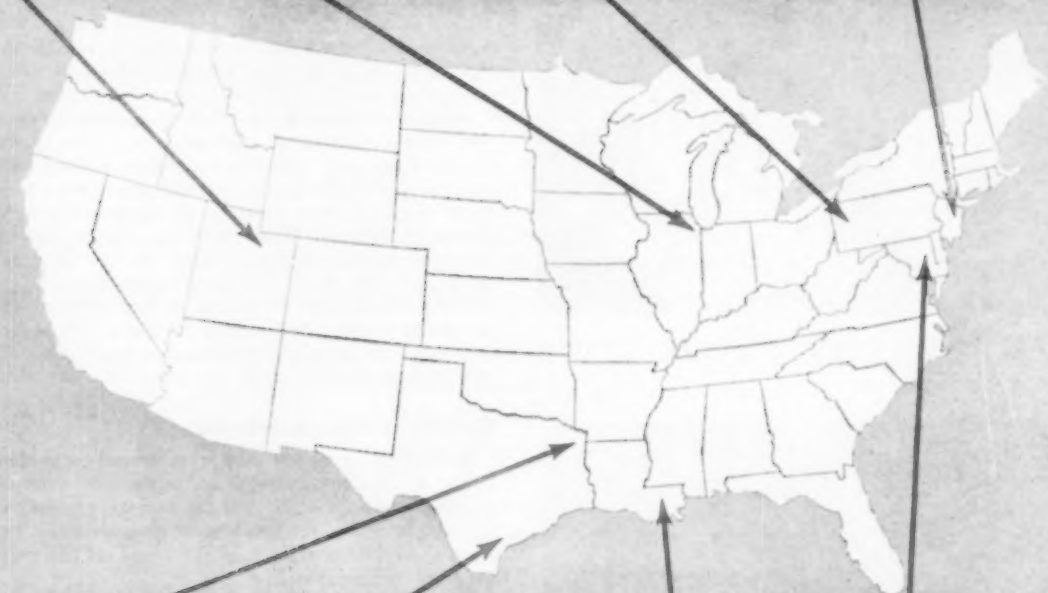

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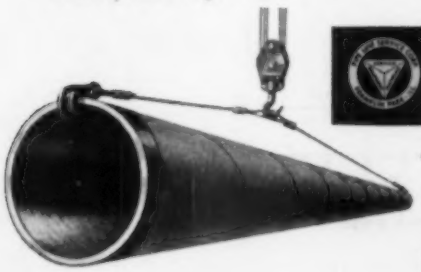

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FIG. 5. Coal-tar enamel coated pipe after six years underground service in sand backfill, showing perfect condition of enamel.[2]

FIG. 6. Corrosion like this occurs under conditions as illustrated in Fig. 4.

"The foregoing illustrations are given for the purpose of showing that enamels made from coal-tar pitch bases are practically immune to deterioration from water absorption."[2]

Another writer[3] has this to say about his experience with water absorption tests:

"Our water absorption tests were started in 1941, to determine the rate of deterioration or water absorption by making careful weighings. Each sample was made exactly the same size by pouring the melted bitumen into a metal mold to form a 1-in. cube. Each specimen was carefully weighed and placed in an 8-oz glass jar, which was filled with tap water and closed with a tight fitting screw cap.

"At frequent intervals thereafter the cube of enamel was removed from the water and carefully wiped dry, weighed to determine the gain in weight due to absorption, and replaced in the jar of water.

"Due to the difference in specific gravity of the various samples, we feel that the basis of comparison should be grams of water absorbed per unit area. Inasmuch as all the cubes are the same size, and have the same area, a true comparison of the absorption rates will be obtained by the weights of water absorbed.

"Additional samples have been placed on test at various times so that approximately 20 samples are now under test (May 1956). The results of some of the tests are plotted on the graph, Fig. 7.

"It is to be noted that the absorptive curves of coal-tar enamel tend to be asymptotic approaching a limit, whereas some of the curves of asphalt enamel show a tendency to increase in water absorption.

"It is well to remember that in the oil and gas industries, the principal interest lies in protecting the outside steel pipe surfaces, while in the water supply industry both exterior and interior surfaces of steel pipe require protection.

"Interior surfaces of steel water pipe protected with materials having high water absorption properties in many instances have small tubercles or blisters formed with water pockets between the protective coating and the pipe surface. (Note Fig. 3.) These tubercles or blisters ultimately break, exposing bare metal. When deterioration commences, a sharp reduction in the carrying capacity occurs. Clogging of the water meters by the deteriorating coating material, and small disintegrated particles of coating material entering customers processing plants cause endless trouble to the water utility.

"Further, electrical protection becomes difficult and may be impossible, depending upon the extent of exposed surface."

Significant Data Developed

Some very significant data were developed in these tests, as Fig. 8 illustrates, showing the amount of water absorbed the first year of the test and the average (grams) per year for the life of the test. This kind of data permits a reasonable forecast of ultimate performance based on the average absorption (grams) per year.

Another of the early investigations developed some interesting conclusions. The test samples were 1-in. cubes, similar to those in the above test. They were carefully weighed, before placing in jars of water (in this case distilled) and were weighed every six months for the duration of the test. This

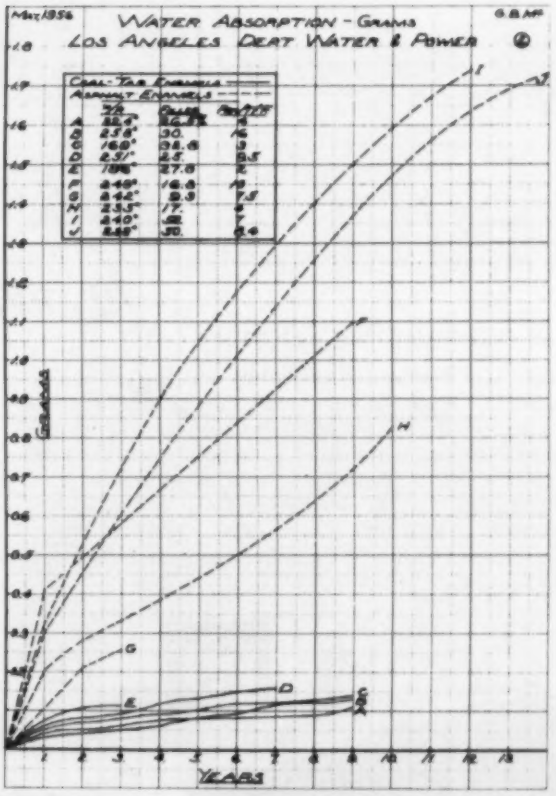

FIG. 7. Water absorptive properties of coal-tar enamel and asphalt enamel.

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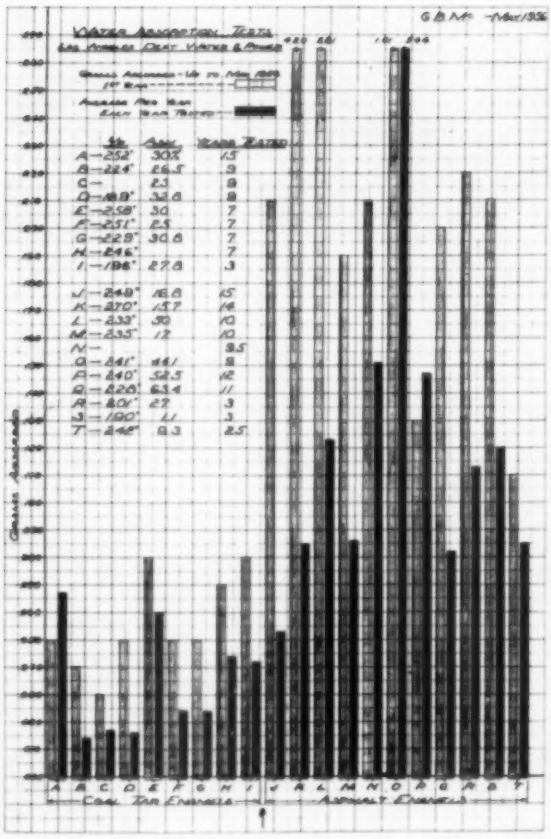

FIG. 8. Data obtained from water absorption tests made by the Los Angeles Department of Water and Power.[3]

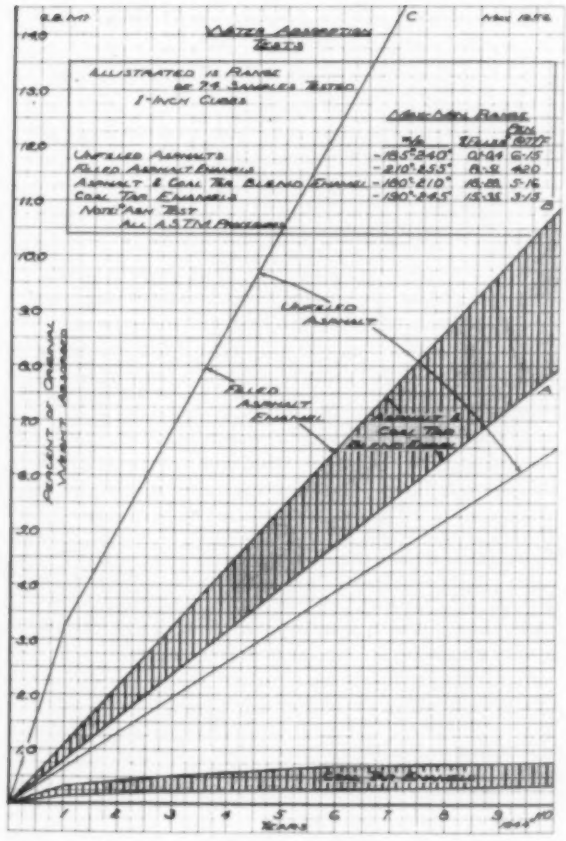

FIG. 10. Water absorption tests with 1-in. cubes developed some interesting conclusions.

was a follow-up to the original API and AGA tests in an attempt to relate these tests to those field performance tests. (Fig. 9.)

In this test the results were determined in terms of percent by weight increase in water absorbed, rather than by grams absorbed or grams per square foot absorbed. The results are not considered quite as effective because of the difference in specific gravity of the samples. For example, the weight per cubic foot of the asphalts (unfilled) may be as low as 55 lb, whereas the filled asphalts or coal-tar enamels may weigh as much as 105 lb per cu ft.

All test results follow the same pattern. They indicate that the rate of water absorption of the coal-tar enamels is much less than that of other commercial products available.

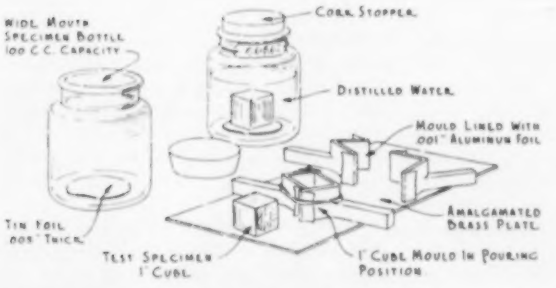
WIDE MOUTH SPECIMEN BOTTLE 100 C.C. CAPACITY
CORK STOPPER
DISTILLED WATER
MOULD LINED WITH .001" ALUMINUM FOIL
AMALGAMATED BRASS PLATE
TIN FOIL .005" THICK
TEST SPECIMEN 1" CUBE
1" CUBE MOULD IN POURING POSITION

FIG. 9. Equipment used in making water absorption tests with 1-in. cubes.

At the time these tests were begun (1932-1934) there were then on the market products in which producers had tried to blend asphalts and coal-tar pitches for the enamel base (before adding fillers) in an attempt to manufacture a material that would have some of the characteristics of today's modified or wide range coal-tar enamels.

This process did not prove successful, as none of these products are available today, however, the data obtained did bring out the fact that the greater quantity of asphalt used in the blends, the greater the water absorption.

In the "A" zone of Fig. 10, the proportion of asphalt to coal-tar pitch was from 8 to 14 percent, whereas in the "B" zone, the proportion of asphalt to coal-tar pitch was from 20 to 30 percent.

Later Tests

In 1949 the Bureau of Reclamation at Denver began a series of water absorption tests on various hot applied coating materials that are more representative of the types available on the market today.[4]

The determinations were made as follows:

"(1) Circular brass discs, provided with a hole in the center for suspension of the specimen, and measuring 2¼ in. in diam by 1/16 in. in thickness, were cleaned, weighed, and dipped in the melted materials. The coatings were applied at temperatures best suited to give a smooth, continuous film without pinholes. Two discs were coated with each material. The coated discs were cooled, weighed, and allowed to stand at room temperature overnight before being submerged in water.

"(2) Glass rods bent to form hooks on both ends were used to suspend the coated discs. Glass fruit jars were filled almost to capacity with tap water and the specimens suspended by the glass rods from screw eyes soldered to the jar lids near the center of the water mass in the containers. The containers were then stored in a 50 percent relative humidity, 73 F constant temperature room.

"(3) When readings were taken, each specimen was removed from the water, the excess water blown off the surface with compressed air, and the weight taken as rapidly as possible.

"(4) The moisture gain was calculated in grams per square foot of surface area, and also as the percent gain based on the weight of the original coating."

In 1955 G. E. Burnett and P. W. Lewis of the Bureau of Reclamation presented a paper[5] before the American Water Works Association annual meeting, in which they described some tests started in the field in 1949, on a penstock at Shasta Dam. Some 20 different coating systems were used, both cold and hot applied to 160 ft of the interior of penstock 5. The balance of the penstock had been lined with AWWA coal-tar enamel, and has been submerged in flowing water since then. They concluded that, although several test coatings were in excellent condition, the length of test did not permit the conclusion that these test coatings will have the durability of the commercially applied AWWA coal-tar enamel that was applied beyond the test section, which was also in excellent condition.

When the last inspection was made, five years after the installation, they reported that, although providing comparatively good protection (rated class B), a hot applied catalytically blown asphalt showed severe surface checking, and

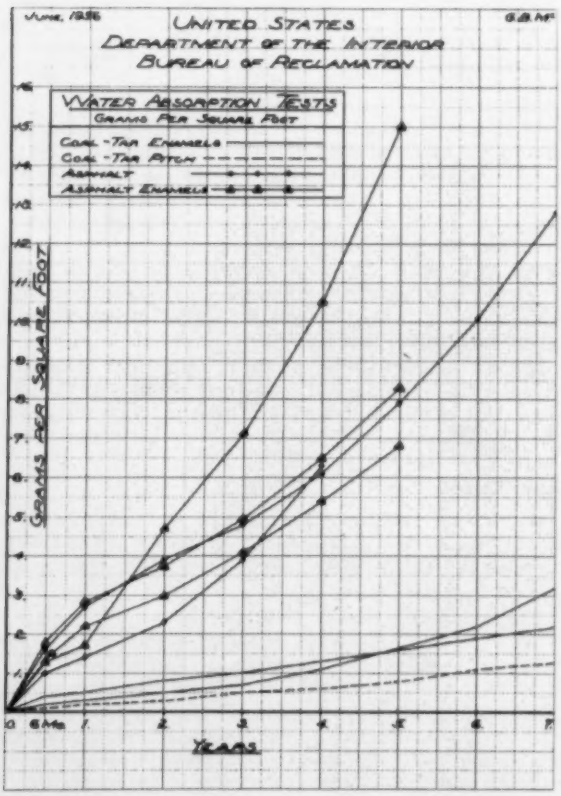

FIG. 11. Both filled and unfilled materials were included in 1949-56 tests, results of which are given here.[4]

FIG. 12. Pipe properly protected and shielded will not fail as this pipe did. Take-up and reconditioning was expensive in this case.

so much water had been absorbed that it could be squeezed out of the coating.

Some person or persons have advanced the theory that not water "absorption" but water "transmission" is the cause of corrosion. The implication is that corrosion does not occur until the moisture contacts the metal. Most corrosion engineers know that it is not the moisture coming in contact with the metal that causes the trouble, but that when a coating becomes waterlogged beyond a certain point, it ceases to have sufficient electrical insulation value to prevent the discharge of line currents that cause pitting. (See Fig. 12.)

In other words, as water absorption by a coating increases, electrical insulation values decrease to a point where economical installation of cathodic protection is not practical. The only solution (that is, if there are not too many holes) is to apply cathodic protection in such quantities and number of installation units as though the pipe were bare. When this is done expenditure for cathodic protection can only be considered as expedient and not as capital investment; yearly fixed charges, operating expense, and maintenance are beyond reason.

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★ ★ ★

Pipeline Corrosion Problems To Be Discussed at Fall Sessions

Corrosion of underground pipelines will be considered at several technical meetings sponsored by the National Association of Corrosion Engineers during the fall months. Events of interest to pipeliners include the North Central Region meeting, October 1-4, 1957, at Hotel Sherman, Chicago; South Central Region meeting, October 1-4, 1957, at Municipal Auditorium, Oklahoma City; Western Region meeting, October 23-25, 1957, at U. S. Grant Hotel, San Diego, California, and the Northeast Region fall meeting, November 12-14, 1957, at the Hotel Penn-Sheraton, Pittsburgh.

A short course to be held at University of Illinois, Urbana December 9-13, 1957, inclusive, will pertain almost exclusively to problems associated with metal corroding in soil and water, and a short course to be held at San Diego concurrently with the regional meeting will be devoted largely to soil corrosion.

Among technical committee meetings to be held at one or more of the regional meetings will be those on internal corrosion of products and crude oil pipelines and tanks, corrosion in oil and gas well equipment, inhibitors, pipe coatings and wrappers, including plastic tapes.

Canadian News Notes

Pembina Pipe Line. Another big construction season for Pembina Pipe Line, Ltd., will add at least 91 miles to its gathering system in the Pembina oil field of west central Alberta and 31.9 miles of 16-in. loop to its main line. Both contracts have been awarded to Universal Pipelines, Ltd., subsidiary of Mannix Ltd., Calgary. By the end of the season Pembina Pipe will have the largest gathering system in Canada, with 446.34 miles in operation. The 1957 construction program involves 39 miles of 3-in., 36 miles of 4-in., and 16 miles of 6-in. pipe.

The loop section will be the most easterly end of the 75-mile line, from Calmar, where a temporary station is located, to the terminus of the main line in the Edmonton refinery area.

Interprovincial. Two projects for Interprovincial Pipe Line Company, in Ontario and Saskatchewan, are in progress, with the latter far ahead of schedule. Majestic Contractors, Ltd., and R. H. Somerville Company, Ltd., are laying 149 miles of 20-in. pipe for extension of the main line from Sarnia to Toronto. The sections are 62 and 87 miles, respectively, for the eastern and western portions.

In Saskatchewan, Fulton Banister, Ltd., was scheduled to complete during June the 24-in. loop of 32.6 miles of main line between Peebles and Kendal, including work at the Glenavon pumping station.

Trans-Canada east. Tenders have been called for construction of approximately 400 miles of 24-in. natural gas pipeline from Toronto to Montreal, for Trans-Canada Pipe Lines, Ltd. No starting date has been specified and the company has not yet had delivery of any pipe, nor has it any contracted supply of natural gas to put through the proposed line. An application for permission to import American gas for the line is pending before FPC, but is coupled with another related application for export of gas from the Manitoba-Minnesota border. Opposition from midwestern states' utilities has suspended action on these applications.

Union Gas. Canadian Bechtel Ltd. has been awarded the contract to lay 140 miles of 26-in. natural gas pipeline for Union Gas Company of Canada Ltd. between the Dawn field (midway between Sarnia and Chatham) and Hamilton, with intermediate takeoff points for several important smaller cities of southern Ontario. This will implement an expansion program held up for two years until approval was secured from FPC for export of American gas.

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Plantation Pipe Line Company

Plantation Pipe Line installed variety of automatic controls in stations three years ago to obtain background knowledge it is now using

PLANTATION Pipe Line Company has recently installed several remotely controlled unattended pumping stations on its system, the design for which was based on operating experience gained from automatic stations built in 1953. In these earlier stations a variety of control equipment was purposely installed with a view to acquiring as much background information as possible for future use.

At that time there were other pipeline systems with remotely controlled stations in operation, but little performance, availability, or economic data had been accumulated.

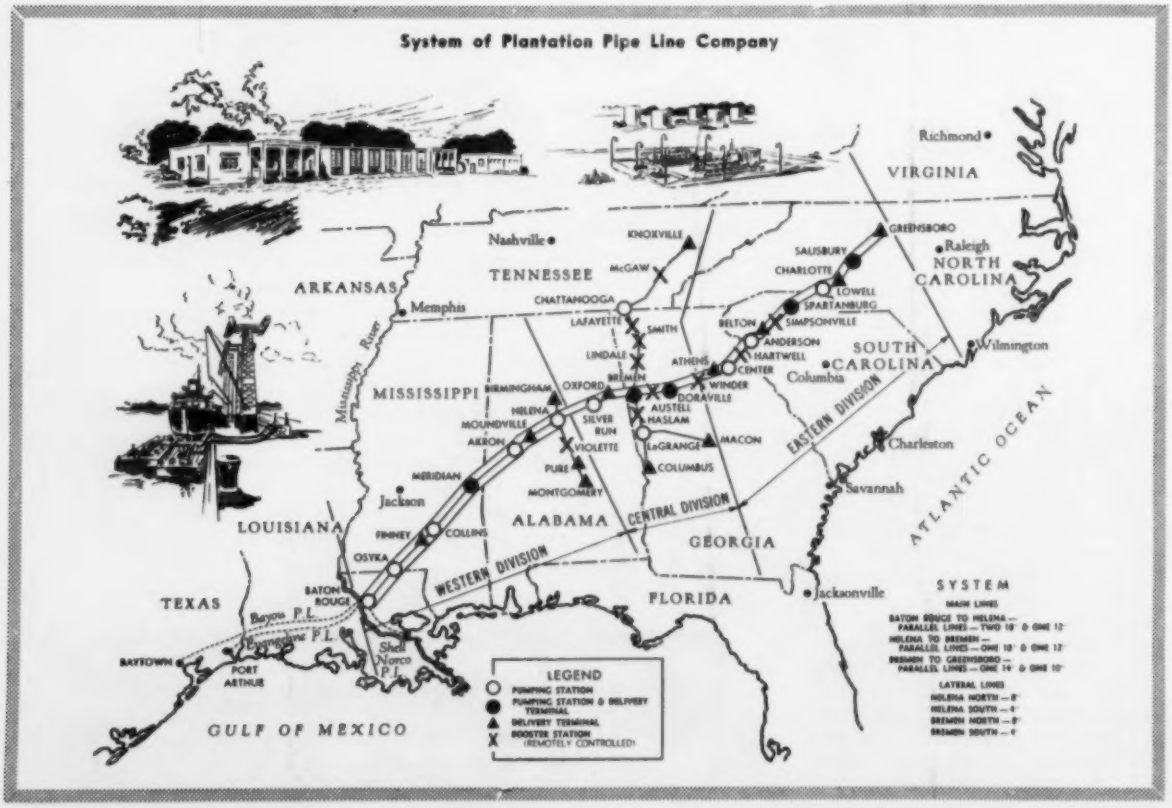
The 1953 installations are single unit pumping stations on lateral lines, one on each of two 4-in. lines and two on an 8-in. line.

The 4-in. line units are driven by 300-hp motors and are controlled by selective dialing of a number through the teletype circuit for start or stop. No other remote control function and no intelligence are transmitted between the station and the control point. Operator at the controlling station uses his local flow meter and motor ammeter for an indication of whether the satellite station is on the line or not.

In small diameter lines with relatively small motors, this type of control has been satisfactory and economical. Transmission of shutdown and failure functions to the control point would be advantageous, and under some circumstances would provide a more efficiently functioning system. Availability and reliability of these stations have been entirely satisfactory.

As power requirements on the 8-in. line were 800 hp, it was decided to transmit all pressures, flow rate, valve positions, and safety alarms to the controlling station and provide the operator with intelligence equivalent to that installed in a manned station.

Microwave radio is used to transmit telemetering and supervisory functions and provide party line voice communication between all points. At the control point there are immediate indications of shutdown functions, which are



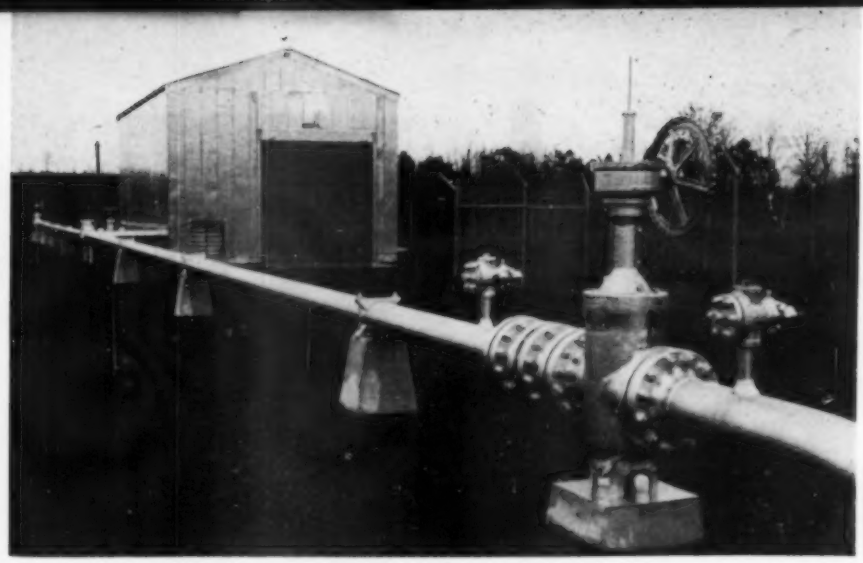


FIG. 1. Pump building. Gate valves are positioned inside the fence and in pipe aboveground.

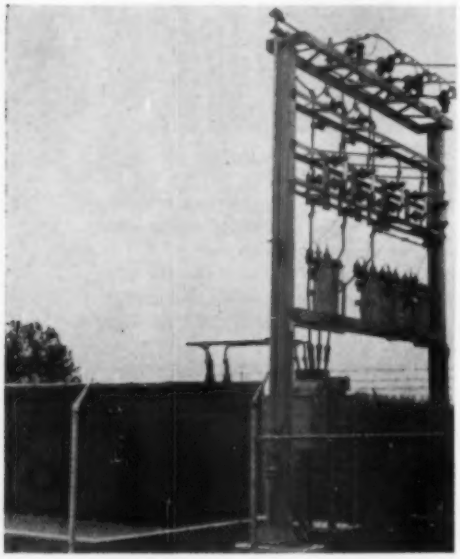


FIG. 2. Outdoor switchgear permits all line and motor breakers, capacitors, and reactors to be positioned at the substation.

corrected automatically when conditions are restored to normal, and lockout functions (mechanical and electrical), which require maintenance attention before restarting the pumping unit. This is a help to the maintenance crews because mechanical and electrical failures are separate indications.

These stations have been in operation for more than three years and have established a satisfactory record of safety, reliability, and availability.

Maintenance of the pumping units, motors, auxiliary equipment, and local control circuits have not imposed any unusual requirements. The normal maintenance personnel have not experienced any difficulty with the station equipment.

Microwave radio requires trained technicians, and a separate crew has been established for performing this function.

Availability has exceeded 95 percent, and this is equivalent to that of manned stations. The safety devices have all functioned, but some were slow in response rates, and accuracies could be improved.

New Station Design

Additional pumping requirements in 1956 necessitated the installation of more pumping units on the 8-in. lateral line and the 10-in. and 14-in. parallel main line. Full head units of 1200 hp for the lateral line and 600 hp and 900 hp, respectively, for the 10-in. and 14-in. main line would fulfill the requirements.

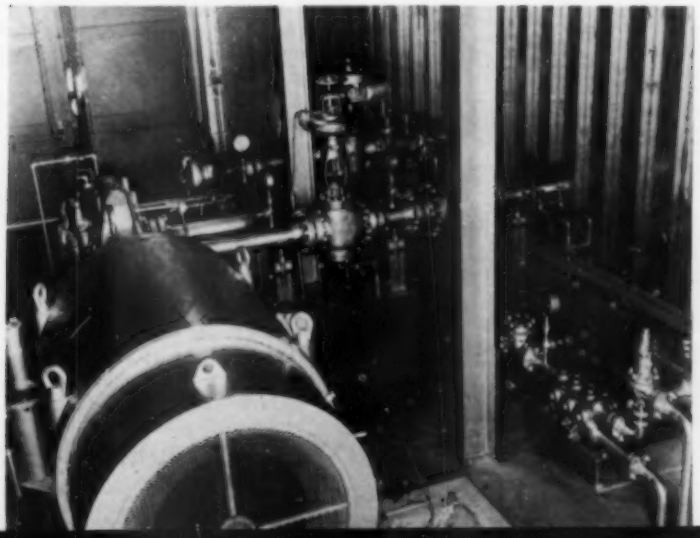
From the backlog of experience with automatic stations, Plantation engineers decided to incorporate the very latest in instrumentation, piping layouts, and equipment. Simplification of installation and accessibility of all equipment were carefully considered in order to realize economical construction and maintenance. Leased wire for control would be used because of economics particular to these stations.

Fig. 1 shows the pipeline and pump building. Direction of flow is from right to left. Gate valves for station isolation are positioned inside the fence and in the pipe where it is aboveground for connection to the station. Detectors flanged to each gate valve permit the pump to be shutdown and restarted automatically for scraper passage.

Substation and switchgear are shown in Fig. 2. Outdoor switchgear permits all line and motor breakers, capacitors, and reactors to be positioned at the substation, thus eliminating some conduit runs and reducing the length of others. Also, in the switchgear building all high voltage has been eliminated. This area is isolated from the buildings by protective fencing.

Interior of the pump building appears in Fig. 3. The suction piping enters the building, and a motorized gate valve is installed, ahead of a tee-type strainer, which protects the pump from foreign particles. Also, in the strainer

FIG. 3. Interior of pump building.



F.G. 4. Low voltage switchgear and control.

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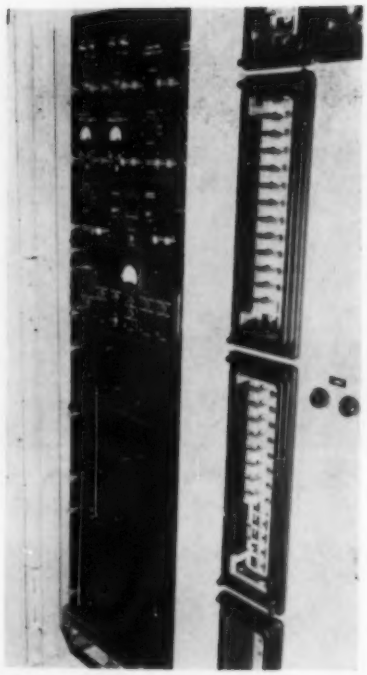

FIG. 5. Instrumentation cabinet.

is an assembly of permanent magnets to catch small pieces of metal that would jam the control valve.

The discharge line contains the control valve and check valve. No motorized discharge valve is used in these stations.

The pump is equipped with mechanical seals whose leakage is collected in a small tank. A float control operates the control of a small injector-type pump, which returns normal seal leakage in the line. If excessive leakage occurs and the normal tank level is exceeded, another float control switch shuts down and isolates the main pump. When this occurs, an alarm circuit is energized and a signal is received at the control point.

A manually operated sump pump returns drained product from the tank to the line. Strain gage cells are attached to the suction and discharge piping for sensing pressure and are used for measurement control, telemetering, and shutdown functions.

On the panel to the left of Fig. 4 are located the incoming line controls. Gages at the top show voltage, amperage, and kilowatts. An annunciator panel with flags gives a local indication of all failures. Breaker controls and protective relays are on the lower portion of this panel.

In the center panel are the pneumatic station controls. The top instrument is the motor load controller, and limits horsepower to 100 percent. Below is the pump suction and outbound line pressure controller. The small

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gages to the right are suction and outbound line pressures.

On the right panel are the motor controls, which include all protective and timing relays for the sequence control circuits. An annunciator shows all lockout functions. Local start and stop buttons are on this panel for the convenience of maintenance personnel. A switch disconnects the remote start for safety during repair operations.

Black cabinet shown in Fig. 5 houses all pressure measuring, telemetering, and protective devices. On the top row, left to right, are suction and discharge pressure amplifiers and their telemetering convertors. On the second row down are low and high pump suction pressure, high line pressure, and inboard and outboard bearing temperature protective devices. On the third row are pump case temperature and vibration protective devices. A common power supply is located on the fourth row. Below are the telemetering transmitters and the junction panel for all sensing elements.

This cabinet is connected to the motor control circuit at the top with short lengths of conductor to a terminal strip on the switchgear.

To the right of this cabinet are mounted the supervisory relays. On a panel to the left of the instrument cabinet are the multiplexing and channel deriving equipment.

These stations have been in operation for three months and have given little trouble. Maintenance is easy because all gear is readily accessible. Protective devices have all performed with exceptional accuracy, stability, and fast rates of response. Elimination of the motorized discharge valve has simplified station piping and sequence control.

If new stations were planned at this time, Plantation engineers would make but few minor changes in this basic design. ★ ★ ★

The Author

William W. Holt, Jr., joined Plantation Pipe Line Company in January 1947, after graduating from Georgia Tech with a degree in mechanical engineering. Since that date he has worked with experimental pipeline equipment. He became the company's head technologist in September 1954. During the World War II, Holt served in the Air Material Command as a performance test pilot. He also attended the Air Force Institute of Technology.

New Technique Fireproofs, Insulates Storage Tanks

A new technique has been developed for protecting gasoline and oil storage tanks from the dangers of fire and evaporation loss by protecting them with perlite insulating concrete.

United States Gypsum Company, Chicago, recently used the new method on three medium-size fuel tanks at its Philadelphia plant. In this case, the company wanted to enlarge one of its buildings that was close to the 50,000-gal fuel tanks but was unable to do so because of municipal fire regulations. Approval was granted, however, after the tanks had been fireproofed with concrete made with perlite — an expanded volcanic mineral.

Additionally the perlite concrete serves as an insulator to minimize evaporation loss, and protects metal tanks from rust and weather and is said to be rot and vermin proof.

July 15th . . .

Equipment Reference Issue

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Pipeline Personals

Millard K. Neptune, formerly general manager of Sahara Petroleum Company, Alexandria, Egypt, will head Texas Eastern Transmission Corporation's expanding products pipeline division. Neptune,

M. K. Neptune

J. D. Bland

who will make his headquarters in Shreveport, Louisiana, will fill the newly created post of executive vice president, products division, and will be in charge of all products pipeline operations.

J. D. Bland, of Shreveport, has been promoted to general superintendent of the petroleum products division. In his new capacity Bland will supervise all operations of Texas Eastern's petroleum products system.

J. Ray Fisher, superintendent of Texas Gas Transmission Corporation's compressor station department, retired June 1. He has been a member of the Texas Gas organization eight years. **J. B. Eaton**

J. R. Fisher

J. B. Eaton Jr.

Jr. will become superintendent of the compressor station department succeeding Fisher. Eaton was formerly assistant superintendent. **T. L. McWilliams,** Memphis, Tennessee, has been named assistant superintendent of Texas Gas Transmission compressor station department succeeding Eaton. McWilliams has been

T. L. McWilliams

H. L. Gibson

a Texas Gas compressor department division superintendent, with headquarters at Memphis, since August 1950. **Hoover L. Gibson,** division 3 superintendent in the compressor station department of Texas Gas has been appointed superintendent of compressor engineering.

W. M. Elmer has been elected executive vice president of Texas Gas Transmission Corporation. Elmer, former senior vice president of the company, will assume his new responsibilities immediately. He will continue to serve as president of Texas Gas Exploration Corporation and as a director of both corporations. **D. G. Sisterson** was elected a director of Texas Gas Transmission. He is principal partner in the firm of D. G. Sisterson & Company, certified public accountants, Pittsburgh and New York. He is a director and member of the executive committee of Morewood Realty Corporation and Metwood Investing Corporation of New York.

G. L. Maciula has been appointed chief engineer of Service Pipe Line Company, replacing **A. H. Newberg.** Newberg resigned June 30 to enter the ministry in the Episcopal Church. **Ellis Orr,** superintendent of the company's Drumright, Oklahoma district, was promoted to assist-

G. L. Maciula

Ellis Orr

ant divisional manager, Missouri-Illinois division, replacing Maciula. Orr will serve as acting division manager during the absence, due to illness, of **J. J. Willenburg,** Missouri-Illinois division manager. Orr's headquarters will be in Galesburg. **J. J. Wright Jr.** was named superintendent of the Drumright district to replace Orr.

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WITH THE PIPELINE CONTRACTORS

● **A. P. Vaughn Construction Company, Box 1144, Fort Worth, Texas.** Has joint venture with Potashnick Construction Company to lay sections 1 and 2 of the Utah to California crude line for *Four Corners Pipe Line Company*. Both sections are 16-in. pipe. Section 1 is 76 miles from the Aneth field in Utah to Kayenta, Arizona; section 2 runs 98 miles from Kayenta to Cameron, Arizona. Work began June 15.

● **Collins Construction Company, P. O. Box 86, Port Lavaca, Texas.** Has contract for laying 37,000 ft of 22-in. pipe for the *City of Los Angeles*, California. Line will serve as ocean outfall for sludge from Hyperion Treatment Plant at El Segundo, and will extend from El Segundo beach to a depth of 300 ft in the Pacific Ocean. Also has 11,000 ft of 4-in. pipe to lay for *Pan American Petroleum Corporation* from McFaddin Beach Dome near High Island to a producing well offshore in the Gulf of Mexico.

● **A. J. Curtis & Company, P. O. Box 1072, Casper, Wyoming.** Has undetermined amount of ¾ to 6-in. city distribution line to lay for *Spokane Natural Gas Company*.

● **American Pipe Coating Contractors, Inc., P. O. Box 89, Jennings, Louisiana.** Has 47½ miles of 3-in. line for *Magnolia Petroleum Company*. Has 6 miles of 4-in. for *Bell Oil Company*. Has 10½ miles of 12-in. line for *Gulf Interstate Gas Company*. Also has 17 miles of 12 and 16-in. gathering system for Anchor-Wate, Inc., (for *American Louisiana Pipe Line Company*).

● **Somerville Construction Company, Ada, Michigan.** Has 67 miles of 10 and 12-in. line from Clare County to Traverse City, Michigan, for *Michigan Consolidated Gas Company*. Also has 60 miles of 10 and 12-in. line between Muskegon and Ludington, Michigan, for the same company.

● **Williams Brothers Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has 212.5 miles 20-in. crude line for *Socony Mobil Oil Company de Venezuela*. Line will extend from San Silvestre field to Puerto Cabello on the Caribbean Coast.

● **C. P. Bartley & Son Pipe Line Construction, P. O. Box 616, Tioga, North Dakota.** Has 110 miles of 3 through 12-in. gas gathering extensions for *Signal Oil & Gas Company* in the Newton, North Dakota, area.

● **Trojan Construction Company, Inc., 1416 N. Robinson, Oklahoma City 3, Oklahoma.** Has contract for takeup and reconditioning 276 miles of 8-in. line for *Sinclair Pipe Line Company* between Jacksboro and Mexia, Texas.

● **Houston Contracting Company, 2707 Ferndale Place, Houston 6, Texas.** Has 43 miles of 30-in. natural gas line for *Texas Eastern Transmission Corporation* between Berne and Athens, Ohio. Also has 35 miles of 30-in. gas line for *Texas Eastern* between Wheelersburg and Athens, Ohio. Has 80 miles of 30-in. gas line for *Texas Eastern* from Kosciusko to Egypt, Mississippi. Has 80 miles of 30-in. natural gas line for *Northern Ontario Pipe Line Crown Corporation* between Uspala and Port Arthur, Ontario.

● **Panama-Williams Corporation, 1418 Melrose Building, Houston, Texas.** Has 76 miles of 4 and 6-in. line for *Phillips Chemical Company* between Pasadena and Sweeny, Texas. Also has 46 miles of 10-in. LPG and natural gasoline line to lay for *Gulf Refining Company* between the company's Waddell plant in Crane County, Texas, to Midland. Contracts for the remainder of this 530-mile line, extending to Houston, are yet to be let.

● **Hood Construction Company, 3002 E. Century Blvd., Lynwood, California.** Has 81 miles of 10-in. line for *Southern Pacific Pipe Lines, Inc.*, beginning west of Lodi and running to a point near Roseville, California; this is second section of firm's 323 mile products line.

● **J. E. Young, Pipe Line Contractor, Inc., 931 E. Rosecrans Avenue, Los Angeles, California.** Has joint venture with Engineers Limited on two sections of the 323 mile *Southern Pacific Pipe Lines, Inc.*, new products line. Contract includes 184 miles of 6 and 8-in. line extending from Roseville, California, to Fallon, Nevada.

● **Dutton-Williams Bros., Ltd., North Canadian Oils Building, Calgary, Alberta.** Has approximately 320 miles of distribution and transmission systems for *Inland Natural Gas Company* in and connecting several British Columbia towns. Project includes 154.5 miles of 12 in. line, 110 miles of 10 in., and remainder from 8 to ¾-in. in Nelson, Savona, Penticton, Castlegar, Kelowna, Kamloops, and Grand Forks. Also has contract for 47.5 miles of 12-in. oil line from Gilbey to Sundre for *Rangeland Pipe Line Company*. Has contract for testing 310 miles of *Westcoast Transmission, Ltd.*, 30-in. line from Taylor, B. C., to M. P. 310; completion is expected in September. Has contract for 50.8 miles of 30-in. oil line for *Trans Mountain Oil Pipe Line Company* between Edson and Minton, Alberta.

● **Banister Construction, Ltd., 625 Northern Hardware Bldg., Edmonton, Alberta.** Has undetermined amount of 2 to 6-in. extensions to existing systems in cities and towns in Saskatchewan, plus approximately 5000 consumer service connections, for *Saskatchewan Power Corporation*. Also has contract for 25 miles of 10-in. line from the Trans-Canada pipeline to the City of Brandon, Manitoba, for *Plains-Western Gas & Electric Company;* this project includes installation of approximately 3000 consumer service connections.

● **H. C. Price Company, Box 1111, Bartlesville, Oklahoma.** Has 71 miles of 30-in. line for *Texas Eastern Transmission Corporation* in the Port Lavaca, Texas, area.

● **Sheehan Pipe Line Construction Company, National Bank of Tulsa Bldg., Tulsa, Oklahoma.** Has 116 miles of 8-in. line for *Buckeye Pipe Line Company* between Huntington and Griffith, Indiana; project includes take-up, reconditioning and relay. Also has 70 miles of 8-in. line to recondition for *Buckeye Pipeline Company* near Cooks Ferry, Ohio.

● **Majestic Contractors Limited, 408 Royal Trust Building, Edmonton, Alberta.** Has gathering system to lay for *Westspur Pipeline* in the Midale, Saskatchewan, area. Has undetermined amount of city distribution system for *Consumer Gas Company* in Toronto. Has 85 miles of 30-in. line — Section 7 — of *Trans-Canada Pipe Line, Ltd.*, natural gas line. This spread, with pipe laying to begin probably in June, is east of Winnipeg through territory largely muskeg and solid igneous rock.

● **Canadian River Construction, 580 Hornby Street, Vancouver, British Columbia.** Has 150 miles of gathering lines in northern Alberta and British Columbia for *Westcoast Transmission Company, Ltd.*

● **Ted Price Construction Company, Electra, Texas.** Has 205 miles of 1 to 8-in. distribution system in Walla Walla, Washington, and Pendleton and Baker, Oregon for *Cascade Gas Company*. Also has 20 miles of 8-in. line to lay for *Sinclair Oil & Gas Company* between the Slocum area, Anderson County, Texas, to Palestine.

● **Fish Service Corporation, M & M Building, Houston, Texas.** Has 67 miles of line for *Florida Pipeline and Storage Company* from Port Everglades to Homestead Air Force Base, Florida.

● **Canadian Bechtel, Ltd., 44 King Street West, Toronto, Ontario.** Has 140 miles of 26-in. line for *Union Gas Company of Canada, Ltd.*, between the Dawn field (midway between Sarnia and Chatham) and Hamilton, with intermediate take-off points to several cities of southern Ontario.

● **Troth Construction Company, Box 592, Britton, Oklahoma.** Has contract for 160 miles of 2 and 8-in. lines for gas distribution to communities in the Aberdeen, South Dakota, area, for *Northern Natural Gas Company*.

● **Fulton Banister, Ltd., 625 Northern Hardware Building, Edmonton, Alberta.** Has 33 miles of 24-in. for *Interprovincial Pipe Line Company* between Peebles and Glenavon, Saskatchewan. Also has 100 miles of 18-in. and 17 miles of 34-in. line for *Alberta Gas Trunk Line Company, Ltd.*, running from Burstall at the Alberta border to Provost, Alberta.

● **Engineers Limited Pipeline Company, 200 Bush Street, San Francisco, California.** Has line for *Pacific Gas & Electric Company* consisting of 37 miles of 20-in., 37 miles of 18-in., and 19 miles of 12-in. to lay from Beehive Bend field to Sacramento, California. Has joint venture with J. E. Young, Pipe Line Contractor, Inc., on two sections of *Southern Pacific Pipe Lines, Inc.*, new products line. Contract involves 184 miles of 6 and 8-in. line between Roseville, California, and Fallon, Nevada.

● **Mannix, Ltd., 322 Seventh Avenue W., Calgary, Alberta.** Has 100 miles of 3 to 12-in. gathering line in the Pembina field to lay for *Pembina Pipeline Company, Ltd.* Has 110 miles of 30-in. for *Westcoast Transmission Company, Ltd.*, between Huntingdon and Kingsvalle, British Columbia. Has 90 miles of 34-in. to lay for *Trans-Canada Pipe Line Company* between Moose Jaw and Candiac, Saskatchewan. Has contract to lay 32 miles of 16-in. loop for *Pembina Pipe Line Company, Ltd.*, between Edmonton and Calmar, Alberta.

● **Mid-States Construction Company, P. O. Box 417, Mt. Vernon, Illinois.** Has 24 miles of ¾ to 6-in. distribution line for *Illinois Power Company* for systems in Carlyle and Hoffman, Illinois. Also has 8½ miles of 6 and 4-in. line for the same company between Hoffman and Carlyle.

FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

● **Potashnick Construction Company, Box 423, Cape Girardeau, Missouri.** Has joint venture with A. P. Vaughn Construction Company to lay sections 1 and 2 of *Four Corners Pipe Line Company* crude line between Utah and California. Both sections are 16-in. pipe; section 1 is 76 miles from the Aneth field in Utah to Kayenta, Arizona; section 2 runs 98 miles from Kayenta to Cameron, Arizona. Work on both sections began June 15.

● **Dunn Bros., Inc., 801 Mercantile Securities Building, P. O. Box 5771, Dallas, Texas.** Has 105 miles of 34-in. for *El Paso Natural Gas Company* between St. Michaels and Navajo Station, Arizona. Has 145 miles of 34-in. line for *Western Pipe Line Company* east of Flagstaff to Topock, Arizona.

● **O. R. Burden Construction Corporation, P. O. Box 5216, Tulsa, Oklahoma.** Has 8 miles of 20-in. to take up in the vicinity of Roland, Arkansas, for *Magnolia Pipeline Company*. Has completed laying a similar amount of new line paralleling take-up job. Has contract for 185 miles of 20-in. crude line for the *Tecumseh Pipe Line Company* to extend from Scherville, Indiana, to Cygnet, Ohio. Has contract for 44 miles of 24-in. line between Sugar Grove and Homer, Ohio, for the *Ohio Fuel Gas Company-Columbia Gas System*. Has been awarded contract to lay 120 miles of 16-in. and 4 miles of 12-in. crude line for *Magnolia Pipe Line Company* between Abilene and Midland, Texas; this project will not begin till late summer.

● **Latex Construction Company of Georgia, Box 56, Northside Branch, Atlanta, Georgia.** Has contract, beginning June 15, for 46 miles of 24-in. line for *Michigan Wisconsin Pipe Line Company*. Line extends southwest from a point near Milwaukee, Wisconsin. Also contract from city of Jacksonville, Florida, for laying 6 miles of 6-in. oil static electric transmission conduit pipeline within the city of Jacksonville. Also has 15 miles of 8-in. distribution service line for *South Atlantic Gas* in Savannah and Chatham counties, Georgia.

● **Eastern Pipeline Contractors, Mercantile Bank Bldg., Dallas, Texas.** Has contract for 89 miles of 6 and 8-in. line for *Gulf Refining Company*, from a point westward from Midland into New Mexico, near Hobbs.

● **R. H. Fulton & Company, Inc., P. O. Box 1526, Lubbock, Texas.** Has 252 miles of 22-in. line for *Colorado Interstate Gas Company* between Rock Springs and Laramie, Wyoming. Has 78.4 miles of 26-in. line in the Minnesota section of *Interprovincial Pipe Line Company's* main line loop. Has contract for sections 3, 5 and 6 of the new *Four Corners Pipe Line Company* line. Section 3 is a 16-in. line 98 miles long from Cameron to Seligman, Arizona; this work begins July 1. Sections 5 and 6 are to begin October 15 to avoid crossing desert during hot summer. Section 5 is 105 miles of 16-in. line from the Colorado River to Twentynine Palms, California and section 6 is a 46-mile 16-in. section from Twentynine Palms to Olive, California.

● **Engineering-Construction Company, First National Bank Building, Tulsa, Oklahoma.** Has contract with *Northwestern Public Service Company* to lay distribution systems in four towns in South Dakota, also has extensions in another South Dakota town. Field office has been set up in DeSmet; work started April 15.

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An entirely new Verti-Line concept for vertical industrial pumps. The discharge head is "Split-to-Pull" making possible many advantages never before available with this type of pump. Here are just a few:

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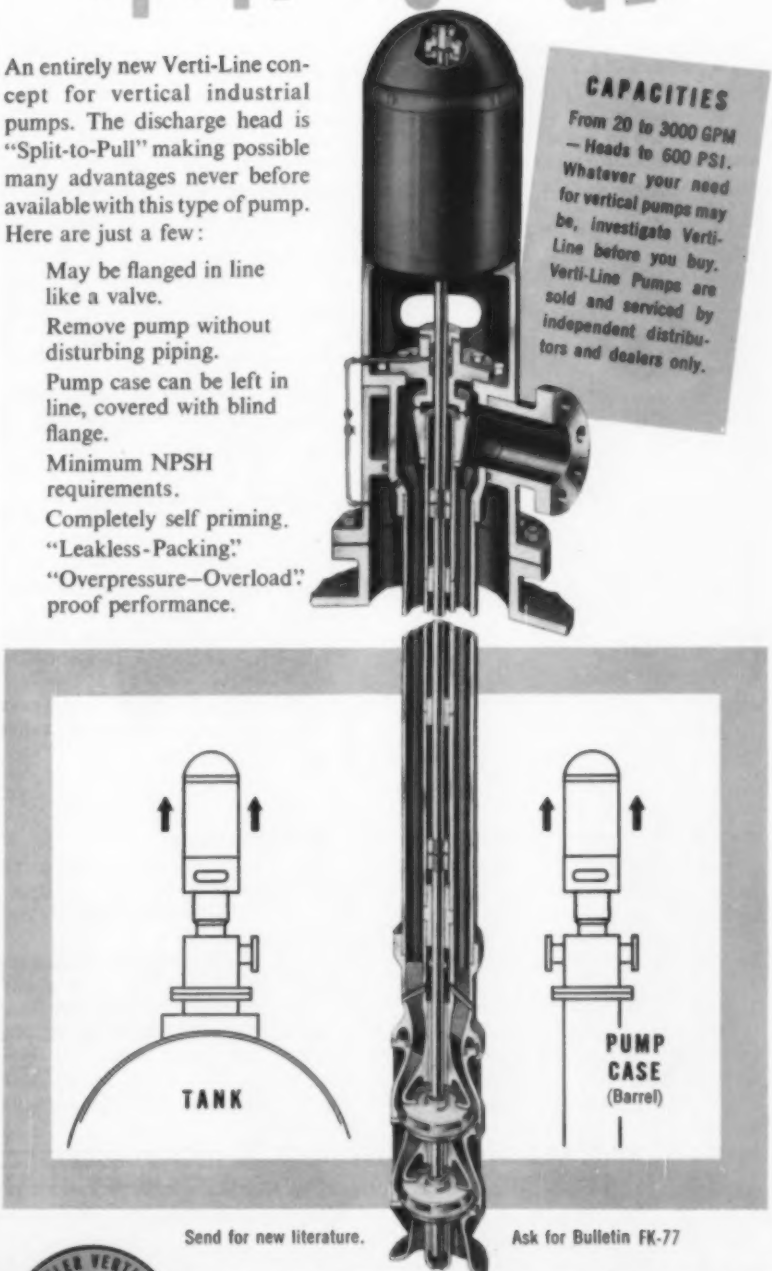

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Pipeline Projects

Applications Ask for $30,322,400 Facilities

Applications by Texas Eastern Penn-Jersey Transmission Corporation and Texas Eastern Transmission Corporation, both of Shreveport, Louisiana, and Algonquin Gas Transmission Company, of Boston, Massachusetts, seeking authorization for the construction and operation of natural gas facilities estimated to cost $30,322,400 and for authority to make increased deliveries of natural gas, have been accepted for filing by the Federal Power Commission.

Penn-Jersey seeks authorization to add 24,000 compressor hp to existing stations on its system extending from the Oakford Storage field in Westmoreland County, Pennsylvania, to Texas Eastern's Compressor Station No. 26, near Lambertville, New Jersey. After installation of the proposed facilities, Penn-Jersey said the transportation capacity of its system leaving the Delmont Station, Westmoreland County, would be approximately 504,911,000 cu ft per day. The estimated cost of these additions is approximately $4,417,800. The facilities would be leased to and operated by Texas Eastern.

Texas Eastern proposes to construct and operate facilities needed to expand its natural gas transmission system by increasing its delivery capacity to enable it to sell for resale an additional 112,203,000 cu ft per day of long-term firm gas and approximately 83,804,000 cu ft per day of winter peaking gas for the winter of 1957-58.

The facilities for which Texas Eastern seeks authorization are: Approximately 96.5 miles of 30-in. loop line between Kosciusko, Mississippi, and Uniontown, Pennsylvania; about 40 miles of 10¾-in. supply laterals; a new 10,250-hp compressor station near Mont Belvieu, Chambers County, Texas; the addition of 31,160 compressor hp to existing stations on its 30-in. line between Beaumont, Texas, and Kosciusko; the addition of about 2200 hp to compressor station No. 27 near Linden, New Jersey; and the necessary metering and regulating stations to make the proposed sales.

Estimated cost of Texas Eastern's proposed construction is approximately $25,904,600.

Algonquin seeks authorization to sell to some of its customers 5,100,000 cu ft daily of winter peaking gas, which it proposes to purchase from Texas Eastern at the existing delivery point near Lambertville. Algonquin's application states that its presently authorized facilities are adequate to render the additional service for which authorization is requested.

Penn-Jersey is a subsidiary of Texas Eastern, which also owns a substantial interest in Algonquin.

FPC Authorizes Offshore Line for Transcontinental

The Federal Power Commission has authorized Transcontinental Gas Pipe Line Corporation to construct and operate facilities, estimated to cost $2,436,000, to connect its system with natural gas reserves from the Gulf of Mexico off the coast of Louisiana.

FPC also authorized Mecom Petroleums, a partnership composed of John W. Mecom, of Houston, and San Jacinto Petroleum Corporation, to sell natural gas produced from leases located in Block 45 and Block 56 fields, offshore Cameron Parish, Louisiana, to Transcontinental.

Transcontinental received authorization for 28.5 miles of 16-in. purchase lateral pipeline and a purchase meter station with appurtenant equipment for receiving offshore gas. Line extends from the purchase meter station in the Block 45 field to a point of connection with Transco's existing 30-in. main line in Calcasieu Parish, Louisiana.

The commission last January 25 temporarily authorized the construction and operation of the facilities and the sale of gas.

The 16-in. line will have a maximum capacity of 110,000,000 cu ft a day while the first year's daily delivery from the area will be 30,663,000 cu ft. The company anticipates sufficient additional acquisitions within two or three years to fully utilize the design capacity of the line.

July 15th . . .

Equipment Reference Issue

Don't miss it!

Gas Storage Project Scheduled for Illinois

The Federal Power Commission has granted Natural Gas Storage Company of Illinois, in Chicago, authority to construct and operate natural gas storage facilities in the Cooks Mills area of Coles and Douglas counties. The estimated cost of the proposed facilities is approximately $3,729,000.

The Cooks Mills area includes two non-associated gas reservoirs known as the Cypress and Rosiclare formations. These formations will be utilized for the underground storage of gas in conjunction with the operation of Natural Gas Storage's present underground reservoir near Herscher, Kankakee County.

Facilities required for the development and operation of the new storage field and for which the temporary authorization was granted consist of wellhead installations, 3.59 miles of field lines, a 1650-hp compressor plant for injection and withdrawal, dehydration facilities, approximately 14.75 miles of 20-in. line to connect the storage field to the 30-in. main transmission line of Texas Illinois Natural Gas Pipeline Company, a meter station at the interconnection, and existing wells drilled into the storage formation.

Natural Gas Storage transports and stores natural gas owned by the customer companies of Texas Illinois and Natural Gas Pipeline Company of America, both of Chicago. The new facilities will enable Natural Gas Storage to inject gas into the Cooks Mills field at an estimated rate of 25,000,000 cu ft per day and to withdraw 25,000,000 cu ft per day for an estimated period of 36 consecutive days. The combined withdrawal in any one day from Cooks Mills and Herscher storage fields will not exceed the presently authorized maximum withdrawal from Herscher of 430,000,000 cu ft per day.

Mississippi Withdraws $11.6 Million Proposal

Mississippi River Fuel Corporation, of St. Louis, Missouri, has notified the Federal Power Commission that it is withdrawing its application proposing the construction and operation of natural gas facilities estimated to cost approximately $11,600,000. The company had proposed to install an additional 7500 compressor hp in stations in Arkansas and Missouri; and 124.5 miles of 26-in. loop line in Louisiana, Arkansas and Missouri.

Slocum Area, Texas Gets Pipeline Outlet

Construction has begun on an 8-in. crude oil line from the Slocum area, southeastern Anderson County, Texas, to Palestine, a distance of 20 miles. The line is being built by Sinclair Oil and Gas Company, with Ted Price of Electra the contractor.

A gathering system also will be constructed to take oil from the Slocum Woodbine and Sub-Clarksville fields. A pumping station one mile north of Slocum will boost the oil into a 12-in. line that Sinclair operates between Troup and Teague, for movement to Houston.

Buckeye Announces Michigan Products Line

The Buckeye Pipe Line Company has announced plans to construct an 8-in. products pipeline from Wayne, Michigan, to the vicinity of Durand, Michigan, a distance of 70 miles. This will afford refiners in the Detroit and Toledo areas a common carrier products pipeline into Central Michigan.

Pipe is on order for the project and it is expected that the line will be completed early in 1958. Estimated cost is approximately $2,000,000.

67-Mile Line to be Laid to Florida Air Base

The Onego Corporation of Uniontown, Pennsylvania, announced that its wholly-owned subsidiary, Florida Pipeline and Storage Company, has entered into a five-year agreement with the United States Air Force for delivery of petroleum products from Port Everglades, Florida, to Homestead Air Force Base at Homestead, Florida, 67 miles south.

Services required under this agreement necessitates the construction of pipeline and storage facilities.

Florida Pipeline has retained Fish Service Corporation of Houston, Texas, to engineer and construct the line. Homestead, a major Air Force installation, is 25 miles south of Miami.

Montana-Dakota Has Several Projects Planned

Montana-Dakota Utilities Company, Minneapolis, Minnesota, has been authorized by the Federal Power Commission to construct and operate the following facilities:

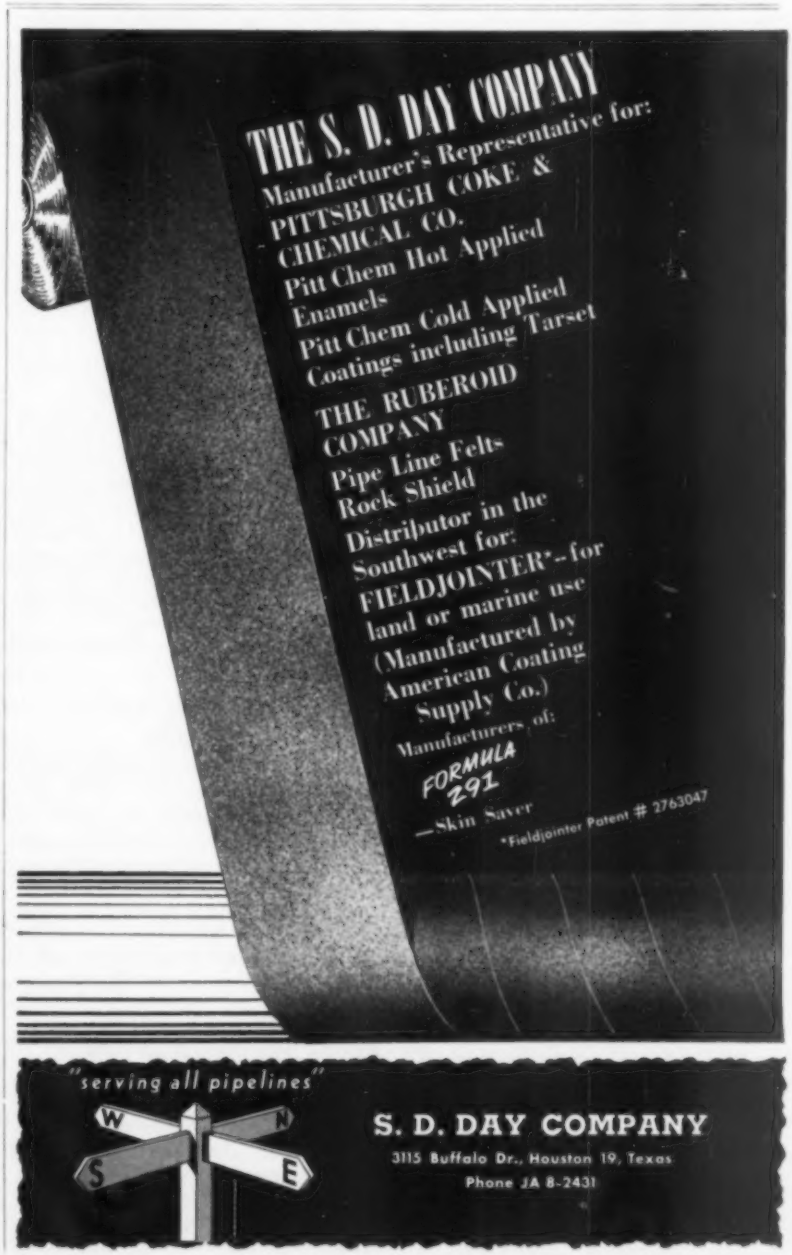
A 1,980-hp compressor station at Dickinson, North Dakota; 6.1 miles of 12¾-in. transmission line between Mandan and Bismarck, North Dakota; new regulating stations to serve Bismarck and Mandan; 4640 ft of 6⅝-in. lateral line near Sidney, Montana, to provide emergency gas service to Montana-Dakota's 44,000 kilowatt steam electric generating plant now under construction; a regulating station to serve the generating plant, and metering and appurtenant facilities to the company's existing desulfurization and dehydration plant in the Garland field, Big Horn County, Wyoming.

In Montana 28.3 miles of 12¾-in. main line pipe from Fallon County to Dawson County, Montana; the installation of a 660-hp compressor unit at its Cabin Creek, Montana, station, together with new cooling facilities for the entire plant, and two 540-hp compressor units and related facilities in its existing Baker, Montana, compressor station.

East Tennessee Natural Plans Compressor Station

East Tennessee Natural Gas Company of Knoxville, Tennessee, has applied for authorization to construct and operate a 3300-hp compressor station. The proposed station would be at a point of connection between East Tennessee and its supplier, Tennessee Gas Transmission Company, near Greenbrier, Tennessee.

East Tennessee said in its application that the proposed station would enable it to avoid an increase in its cost of purchased gas due to a lowering of system load factor.



FOR FURTHER INFORMATION ON ADVERTISED PRODUCTS, SEE READER SERVICE CARD

Contracts Awarded for Four Corners Pipe Line

Contracts have been awarded by Four Corners Pipe Line Company on 485 miles of the 750-mile project. The Four Corners system will extend from northwest New Mexico and southeast Utah to Los Angeles, California.

Contracts went to R. H. Fulton and Company, Lubbock, Texas; A. P. Vaughn Construction Company, Fort Worth, Texas, and Potashnick Construction Company, Cape Girardeau, Missouri.

Construction of some sections got underway in June, according to R. G. McIntyre, president of Four Corners.

Contracts for the 750 miles have been broken into nine sections — 76 miles from the Aneth field of southern Utah to Kayenta, Arizona, Section 1; 94 miles from Kayenta to Cameron, Arizona, Section 2; 98 miles from Cameron to Seligman, Arizona, Section 3; 104 miles from Seligman to the Colorado River, Section 4; 105 miles from the Colorado River to Twentynine Palms, California, Section 5; 112 miles from Twentynine Palms to Olive, California, Section 6; 46 miles from Olive to Los Angeles, Section 7; 86 miles of 12-in. pipe from the Bisti field of New Mexico to the Red Mesa compressor station to be constructed about 35 miles southeast of Bluff, Utah, Section 8; 33 miles of 6, 8, and 10-in. feeder lines connecting various other fields in Utah and New Mexico, Section 9.

The first seven sections will be of 16-in. pipe.

The Potashnick and Vaughn firms jointly will construct Sections 1 and 2, and Fulton will build Sections 3, 5, and 6.

Sections 1 and 2 got started in June; Section 3 was scheduled for July 1, and Sections 5 and 6 will start about October 15. The October date was scheduled to avoid summer work in the California desert areas.

McIntyre said contracts for Sections 4, 7, 8, and 9 and for construction of a major crossing at the Colorado River will be awarded in the near future.

Shell Pipe Line Corporation is acting as agent for the project. Owners of Four Corners are Continental Pipe Line Company, Gulf Oil Corporation, Richfield Oil Corporation, Shell Oil Company, Standard Oil Company of California and the Superior Oil Company.

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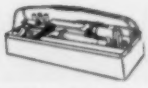

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Texaco-Cities Service Building Products Line

Texaco-Cities Service Pipe Line Company has under construction a 6-in. products pipeline that will extend from East Chicago, Indiana, 170 miles to the Grand Rapids, Michigan, area.

Pumping stations will be built at East Chicago and in the Grand Rapids, area.

In addition to deliveries in the Grand Rapids area, initial deliveries from the system will be made in the Griffith and South Bend, Indiana, areas.

Initial operations are scheduled for late summer.

Pioneer Gathering to Serve Shut-in Wells

Pioneer Gathering System, Inc., wholly-owned subsidiary of Pioneer Natural Gas Company, has received FPC approval to build facilities to take gas from Val Verde, Sutton, and Schleicher counties, Texas.

The system will consist of 70 miles of pipeline and will provide an outlet for wells that have been shut in. Initial capacity will be about 70,000,000 cu ft a day.

Pacific Northwest Makes Applications for Additions

Three applications have been filed by Pacific Northwest Pipeline Corporation, of Salt Lake City, Utah, to construct and operate natural gas facilities in Washington, Colorado, and Idaho.

Pacific Northwest proposes to construct 34.5 miles of 6 and 4-in. lateral lines from its 26-in. line in Snohomish County, Washington, to Grotto, Washington.

Another proposal is for 4.5 miles of a 3½-in. lateral line from its existing 6⅝-in. Uravan lateral line to Union Carbide Nuclear Company's plant at Slick Rock, San Miguel County, Colorado.

In addition, Pacific Northwest proposes to construct 41 miles of 6⅝-in. line from its 6⅝-in. Coeur d'Alene lateral to a metering station at the Bunker Hill Company plant near Kellogg, Shoshone County, Idaho.

FPC Approves Request of Mich.-Wis. for Loops

The Federal Power Commission has granted Michigan Wisconsin Pipe Line Company, of Detroit, Michigan, temporary authorization to construct and operate 22 miles of 24-in. loop line in Illinois and Wisconsin at an estimated cost of $1,823,000.

The company, in its application, said that the construction of the two 11-mile segments would result in the complete looping of its main line serving Wisconsin and provide a safety factor in the event of a line break.

Michigan Wisconsin said that during the 1957 construction season it will install the unfinished portion of its authorized main line looping and that this construction is immediately adjacent to the proposed lines. Substantial expense would be averted by constructing the additional facilities at the same time, the company said.

Cities Service Gas Given Temporary Permit by FPC

Cities Service Gas Company, of Oklahoma City, Oklahoma, has been authorized temporarily to construct a 2700 hp addition to its Blackwell compressor station in Kay County, Oklahoma; 15 miles of 26-in. pipeline replacing an equal length of dual 16-in. line in Johnson County, Kansas; and 6.59 miles of 30-in. line replacing an equal length of 16 and 18-in. line in Johnson County.

83-Mile Line, Three Compressor Units Planned

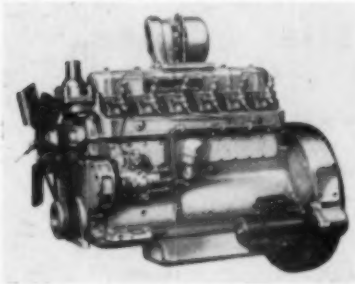
Federal Power Commission has granted Permian Basin Pipeline Company, of Omaha, Nebraska, temporary authority to construct 83 miles of 16-in. line from its interconnection with the proposed gathering facilities of Pioneer Gathering System, Inc., to Permian's existing facilities at Spraberry, Texas. In addition, Permian proposes to construct a compressor station consisting of three 1320-hp units. The estimated cost of the proposed facilities is approximately $5,053,400.

NEW Pipeline Equipment

• machinery • supplies • services

For more information on items described here in brief, use the handy reply card and circle the corresponding numbers

Diesel Engine. Latest Waukesha supercharged engine model, the 197-DLCS, is a compact and powerful heavy-duty, 6-cylinder, 4-cycle, full diesel engine of 302 cu in. displacement. Supercharged diesel offers lively acceleration, clean burning, prompt starting, a tremendous reserve of



power, and greater over-all economy. Without an intercooler the maximum power available from the Model 197-DLCS Turbi-Diesel is 131 hp at 2800 rpm. Without positive drive from the engine, the parasitic load decreases at part engine load, which improves over-all fuel economy throughout the speed range. *Waukesha Motor Company.*

Circle number (81) on reply card.

Truck Carrier. Maximum ruggedness and mobility are combined in the especially designed carrier now available as optional equipment with the Pitman Hydra-Lift, Model 60 HB. Also new is a high mounted boom which makes it possible to haul much higher capacity loads on any truck a Hydra-Lift is mounted on. Hydra-Lift requires only 44 in. of space behind a truck cab and has a lifting capacity of 6500 lb. *Pitman Manufacturing Company.*

Circle number (82) on reply card.

Digital Data Control Systems. Electro-Span is a new digital data transmission and control concept used for highly accurate measurement, control and indication of numerous industrial operations. All systems will perform on commonly used communications channels — telegraph circuits, telephone lines, VHF radio or microwave links. One of the most common examples of liquid level gaging is found in petroleum tank farms. Electro-Span tank gaging system provides a visual gage at tankside, transmission of data to a central location, and record of information by lamp indicator, automatic electric typewriter, punched card, punched tape, or graphic chart. It will automatically show sequential readout of a number of tanks or of a single tank as well as average temperature of tank contents.

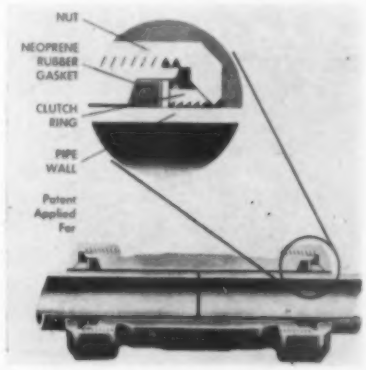
Electro-Span used for pipelines transporting oil, fuel and gas provides for flow, pressure, temperature and malfunction warning with supervisory control. *Bendix Aviation Corporation.*

Circle number (83) on reply card.

New Diesel Safety Switch. New temperature-and-pressure-sensitive switch designed to ring the bell on overheating diesel engines before internal damage results has been developed. Safety switch responds to abnormal temperatures (up to 250 F) or pressures (to 70 psi) to stop or idle the engine, or set off an alarm. Switch actually comprises 2 separate systems, 1 for temperature measurement, 1 for pressure measurement. Temperature system is a remote bulb, capillary and diaphragm assembly that measures engine coolant temperature. Pressure system measures engine lubricating oil. As the temperature rises or the pressure drops to danger levels, small, precision-acting switches on each system trip off the final engine control element or the alarm circuit. *Minneapolis-Honeywell Regulator Company.*

Circle number (84) on reply card.

Threadless Pipe Fittings. Fittings will withstand traction forces up to 3600 lb and hydro-static pressures ranging from 450 psi on 2-in. pipe to 5000 psi on ½-in pipe. Superior gripping action is achieved through a specially designed brass clutch ring with internal serrations which grip the pipe wall as the fitting nut is tightened. At the same time, a Neoprene gasket is compressed against the pipe wall. Thus, a permanent seal against leakage of gas or



liquid, and resistance to abnormal vibration, contraction or expansion is achieved. *Telsco Fittings Division.*

Circle number (85) on reply card.

Automatic Tank Selector System. Controlling the filling of storage and settling tanks, system uses a pneumatic circuit, with a selector-controller and level transmitters directing operation of pneumatic fill valves. The system is said to be extremely accurate, reliable and economical. In operation, the ATS selector-controller automatically senses the liquid level of each tank in the system through the level transmitter and then automatically opens the fill valve if tank requires filling, or automatically cycles to next tank if filling is not required. This is the scanning operation which can be continuous or intermittently cycled as needed, requiring only one second per tank. *Mason-Neilan, division of Worthington Corporation.*

Circle number (86) on reply card.

To Pipeline Readers

We shorted you on new equipment and literature in this issue to bring you a very special issue on July 15 — the Equipment Reference Issue. This is a full issue devoted entirely to new equipment, tools, services, etc. for pipelining. A highly successful idea started some two years ago, it is the number one showcase of the most important new tools developed each year.

Recently we sent letters to all leading manufacturers and suppliers for the pipeline industry. We asked them for their most significant developments in new tools, products and services. In reply has come the most astounding lineup of short articles on pipeline equipment ever assembled for publication.

Just a few of the new products being offered to the pipeline industry include: A new low cost pipeline bridge — easy to use cathodic protection tests boxes — new 120 channel microwave system — two new supercharged gas engines for pipeline service. These are but a few of the subjects that will be discussed in the Equipment Reference Issue.

To stay on top of industry's newest developments, be sure to read your Equipment Reference Issue to be published July 15.

James A. LeVelle
Engineering Editor

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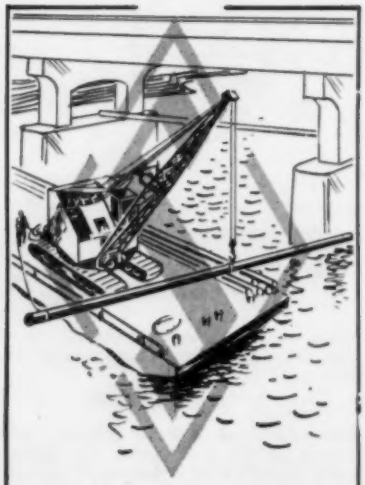

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SIGN OF TRANSMISSION LINES — SATISFACTION DISTRIBUTION SYSTEMS

Gas Detector. A system which warns against excessive accumulations of harmful gases is being manufactured again. One of the features of the unit, which is called the Atlas Permanent Gas Detector, Model 520, is its flexibility. Panel can be large or small to suit the location, and a loud, outside warning alarm can be incorporated. Or, it may be designed to open or close valves, turn on fans, open doors or operate other electrically-controlled devices. It consists of an instrument control board and detector stations which are connected to the control board with a 3-wire conductor cable. In land installations main panel may be situated near a telephone switchboard or in a control room. *Atlas Laboratories, Inc.*

Circle number (87) on reply card.

Automatic 10-In. Balanced Valves. Designed to accommodate their new high-capacity Duo-Rotor Meter line, Granberg Corporation has announced the addition of a new 10-in. balanced valve. This valve has hydraulically balanced closing action that protects the entire system by eliminating the slamming effects of line-shock upon closing. It can be furnished complete with pre-control and linage so that the valve automatically shuts off when the pre-determined gallonage has registered through the meter. Valve can also be used as a control valve, where case of opening, soft closing and positive shut off is required. It is adaptable to remote operation by air, hydraulics or electrical means, etc. *Granberg Corporation.*

Circle number (88) on reply card.

Pressure Ratio Control for Superchargers. Pressure ratio control, designed to maintain maximum power over a wide variation of engine speeds and ambient conditions in supercharged industrial diesel engines, has been developed. It consists of a control unit and a bypass valve, through which greatly improved diesel engine torque characteristics can be obtained and sea level horsepower maintained at high altitudes. Basically, the unit controls the amount of diesel engine exhaust gases used to drive the turbocharger's turbine wheel. *The Garrett Corporation, AiResearch Industrial Division.*

Circle number (89) on reply card.

New Pushbutton Switch. A new "typewriter" pushbutton switch for manual keyboard control of electric equipment is being marketed. Developed for rapid-repeat, one-finger operation, its extremely precise, low-force characteristics give the new switch both snap-action and tap-action. New switch employs a single-pole double-throw precision subminiature basic switch for snap-action reliability. Switch and actuator can be operated at frequencies up to 300 times per minute. The removable contoured ½-in. diameter plastic button is keyed to prevent rotation. *Micro Switch, a division of Minneapolis-Honeywell Reglator Company.*

Circle number (90) on reply card.

Low Pressure Breather Valve. A new low pressure breather valve, Model ST. 9749, is available in a complete range of sizes from 4 through 12 in. Valve incorporates a diaphragm type seal and thermosetting phenolic seat, and provides greater safety, lighter weight, increased flow capacities, and a tighter seal below set operating valves, than has heretofore been available in comparable equipment. *Shand & Jurs Company.*

Circle number (91) on reply card.

1000 Remote Switching Functions. A supervisory control system that allows more than 1000 different codes to be transmitted over a single 2-way channel has been unveiled. New system will control and continuously supervise hundreds of functions at remote locations. Previous systems did not have the capacity and flexibility of the new equipment, which also is capable of alternate use with teletype. It is particularly suited for control of pipelines and similar applications where operators at one or more locations can control equipment at distant points and get positive identification that each job is done. It will do far more than previous equipment, yet represents a simplification of components, is substantially smaller in size, has lower power requirements and cos'ts less. *Hupp Electronics Company, a division of Hupp Corporation.*

Circle number (92) on reply card.

Position Indicator/Controller. Operation and position-indication of remotely located valves, gates, feeders, etc. is possible with new Synchro-Scan position indicator/controller units. These units permit the remote modulation and continuous indication of valves or similar devices. This is accomplished through the transmitter package which has a 3-position switch mounted on its face to control the device. A small voltmeter-type indicator graduated from 0 percent to 100 percent indicates the percent of opening. At the receiving end, another packaged unit contains the control relays and the regulated d-c voltage supply used to transmit the position indication. *Builders-Providence, Inc., division of B-I-F Industries, Inc.*

Circle number (93) on reply card.

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DRILLING RIG LOCATOR

SUMMER 1957

A Directory of Contract Drilling Rigs

the Petroleum Engineer
DRILLING & PRODUCING

P.O. Box 1589 Dallas 21, Texas

THE PETROLEUM ENGINEER'S Summer

DRILLING RIG LOCATOR

In its second year of publication, this exclusive directory of contract rotary and cable tool rigs in the U.S. and Canada now has a new OFFSHORE RIG LOCATOR. *Here's what it contains:*

- **Contractor's name and address**
- **Rig number or name**
- **Type power and fuel**
- **Total hp on main mud pumps**
- **Drawworks make and model**
- **Hp available to drawworks**
- **Rated drilling depth**
- **Current location**

This is the sixth edition of **THE PETROLEUM ENGINEER'S** exclusive and original **RIG LOCATOR.** It has continued to grow and now includes rig data from nearly 775 drilling contractors in the U. S. and Canada. Rig activity took a sharp upward turn the first of June, and this increase is reflected in the larger number of rigs reported here.

This directory service is offered the industry at no expense to the contractor listing his rigs. It has been gratifying to learn that a considerable number of drilling contracts had their beginning when an operator located the rig he needed and where he needed it from the pages of the RIG LOCATOR. It is the hope of the publishers that this editorial feature will continue to grow in size and in utility to the oil industry.

A new section. With each edition of the RIG LOCATOR published since October 1955, new and improved ideas have been incorporated in it for maximum use. The Summer edition published last March was individually bound and glued into the back of that issue. This new feature made it possible to extract the directory intact for filing and further use.

Last month in PE's *Special Offshore Operations Report*, a special section entitled **"Offshore Rig Locator"** was included. Not only did it contain essential specifications on both contractor and oil company offshore drilling rigs, but also listed the type of offshore drilling unit, offshore location designation and depth of water. It was so well received that your editors decided to make this feature a permanent part of the regular editions of the RIG LOCATOR. We are happy to include it as a new section at the end of this directory.

Your suggestions and comments on how the RIG LOCATOR might be improved are always welcomed. Just write the Rig Locator Editor, The Petroleum Engineer, P. O. Box 1589, Dallas 21, Texas.

How to use the RIG LOCATOR. Locations of contract rigs are shown by states and counties (or parishes) in the U. S. and by province and area in Canada. If you are interested in drilling a given well in a certain county, parish, or area, in the case of Canada, and this well could be drilled most efficiently by a certain type rig, you can easily locate those contractors who operate rigs in your area of interest. If the rig you are looking for is not shown in the county where you want to drill a well, look under adjacent counties. Once the rig has been located, and the contractors name ascertained, go back to the alphabetical listing of contractors to obtain his mailing address.

Use of abbreviations. In a directory of this type where certain specifications are included, it was necessary in the conservation of space to make some abbreviations. Under the column of "type power," the following abbreviations apply: Dsl for diesel; gaso for gasoline; stm for steam; btne for butane; and dsl elec for diesel electric. In listing drawworks make and model number, it was necessary to abbreviate the manufacturer's name. Some of these abbreviations are well known; others had to be made to fit the available space. Here's the code we used:

Manufacturer's Company Name	Abbreviation
ALCO Products, Inc. (formerly Beaumont Iron Works Div. of American Locomotive Co.)	ALCO-BIW
Allis-Chalmers Manufacturing Co.	Allis Chmrs
American Iron & Machine Works	Amer
Ansaldo	Ansaldo
Beaumont Iron Works (See ALCO Products Inc. Name no longer officially used)	ALCO-BIW
Bethlehem Supply Co.	Beth
Big Four Machine & Supply Co.	Big Four
The Brewster Co., Inc.	Brwstr
Bucyrus-Erie Co.	B. Erie
Cardwell Manufacturing Co., Inc.	Crdwll
Clark Brothers Co., Inc.	Clark
Fred E. Cooper, Inc.	Cooper
Continental-Emsco Co.	Emsco
Cummins Engine Co., Inc.	Cummins
George E. Failing Co.	Failing
Franks Division of Cabot Shops, Inc.	Frnks
General Machine Co.	Gen Mach
Hacker Machine & Supply Co.	Hacker
Hopper Machine Works, Inc.	Hopper
Houston Tool Co.	Hou
Howard-Turner Machine Works	Howard Turner
Ideco, Inc.	Ideco
Ingersoll-Rand Co.	Ingersoll
Jones, Shelburne & Guffey Co.	JS&G
Joy Manufacturing Co.	Joy
Mayhew Supply Co., Inc.	Mayhew
Lee C. Moore Corp.	L. C. Moore
Lucey Export Corp.	Lucey
Muskogee Iron Works	MIW
The National Supply Co.	Natl
Oil Well Supply Division (U. S. Steel Corp.)	"Oilwell"
Reich Bros.	Reich
Spencer-Harris Machine & Tool Co.	Spencer
Stardrill-Keystone Co.	Star
Texas Iron Works, Inc.	TIW
Unit Rig & Equipment Co.	Unit
Wagner Morehouse, Inc.	Wgnr-Mrhse
Walker-Neer Manufacturing Co., Inc.	Wlkr-Nr
Waldrip Engineering Co.	Wldrp
Well Machinery & Supply Co., Inc.	Ft. Wrth
Wheeling Machine Products Co.	Wheeling
The Wheland Co.	Whlnd
Wichita Tool Supply Co.	Wich
Wichtex Machinery Co., Inc.	Wichtex
Wilson Manufacturing Co., Inc.	Wlsn

U. S. Drilling Contractors

ROTARY AND CABLE TOOLS

ALPHABETICAL LISTING

Abb Drlg Co
300 Oil & Gas Bldg
Wichita Falls Tex

Ace Drlg Co
1800 Republic Natl Bk Bldg
Dallas Tex

Admiral Drlg Co
2030 Gulf Bldg
Houston 2 Tex

Advance Drlg Co
Box 511
Mt Vernon Ind

Ainsworth Inc
1002 Union Natl Bk Bldg
Wichita Kans

Akin & Dimock
714 Holliday St
Wichita Falls Tex

Alan Drlg Co
807 Oil and Gas Bldg
Wichita Falls Tex

Aldridge and Stroud Inc
Box 962
Odessa Tex

Allen & Morris
820 Alamo Natl Bldg
San Antonio Tex

Allen Drlg Co
4410 Venable Ave
Charleston 4 W Va

W C Allen
Box 263
Oil City Pa

B F Allison Drlg Co
626 Patterson Bldg
Denver Colo

Alvon Drlg & Expl Co
Box 201
San Angelo Tex

American Drlg Corp
Box 177
Graham Tex

Anderson Drlg Co
730 Wichita Natl Bank Bldg
Wichita Falls Tex

Anschutz Drlg Co Inc
Box 1466
Casper Wyo

An-Son Drlg Co
3814 N Santa Fe
Oklahoma City 18 Okla

An-Son Gulf Drlg Co
716 Hibernia Bldg
New Orleans La

Appell Drlg Co
Box 330
Alice Tex

Appling Drlg Co Inc
Box 69
El Campo Tex

Armstrong & Horn Drlg Co
640 Milam Bldg
San Antonio 5 Tex

Arrow Drlg Co
407 Philtower Bldg
Tulsa Okla

Ashby Drlg Co Ltd
738 Meadows Bldg
Dallas Tex

Austin Drlg Co
Box 1240
Seminole Okla

Austin-Dunham Inc
Box 1240
Seminole Okla

B & B Drlg Co
Whitlash Mont

B & G Well Maintenance
Box 6825
Houston Tex

B B M Drlg Co
673 San Jacinto Bldg
Houston 2 Tex

B J & M Drlg Co Ltd
160 S Fairfax Ave
Los Angeles Calif

B-M Drlg Co Inc
Box 5218
Bossier City La

Baird & Pfeifer Drlg Co
316 Kittredge Bldg
Denver Colo

Baker & Taylor Drlg Co
712 First Natl Bk Bldg
Amarillo Tex

Dorris Ballew Inc
Box 561
Natchez Miss

Bar-Lee Drlg Co
Box 7264
Tulsa Okla

Barnes Core Drlg Co
1350 Roberts Ln
Bakersfield Calif

Barnwell Drlg Co Inc
Box 1748
Shreveport La

Barrett Petroleum Co
423 Masonic Bldg
Shawnee Okla

Barry Well Drlg Co
Fallon Nev

Basin Drlg Co Inc
523 Frederica St
Owensboro Ky

Bass Drlg Co
905 San Jacinto Bldg
Houston 2 Tex

Harry Bass Drlg Co
1403 Magnolia Bldg
Dallas Tex

Robert M Bass Drlg Contr
Box 471
Kilgore Tex

Bateman Drlg Co
601 Texas Co Bldg
New Orleans La

Bay City Drlg Co Inc
Box 1389
Bay City Tex

Beard Drlg Co
Box 568
Duncan Okla

Beard Drlg Co
900 NE Military Dr
San Antonio Tex

Beardmore Drlg Co
827 Beacon Bldg
Wichita Kans

Beckman Inc
Box 1524
Muskogee Okla

Bennett & Roberts Drlg Co
Drawer 633
Russell Kans

Bennett Drlg Co
1381 E 26th St
Tulsa 14 Okla

Lowell Bernhardt
2469 Grand River
Detroit 1 Mich

Berry Drlg Co
Box 67
Saint Jo Tex

L E Bever Drlg Co
1700 W Louisiana
Midland Tex

Big Chief Drlg Co
Box 8837
Oklahoma City 14 Okla

Big Horn Drlg Co Inc
Box 2068
Casper Wyo

Big Seven Drlg Co
311 Wright Bldg
Evansville Ind

Big West Drlg Co
1321 Oil and Gas Bldg
Ft Worth Tex

Big X Drlg Co Inc
2905 First Natl Bldg
Oklahoma City Okla

Black Drlg Co
525 Petroleum Bldg
Abilene Tex

Black Hills Drlg Co Inc
218½ W Main
Newcastle Wyo

Blackstock & Bradley Drlg Co
810 Braniff Bldg
Oklahoma City 2 Okla

Blount Drlg Co Inc
114 Central Bldg
Midland Tex

Bodard Drlg Co
313 Masonic Bldg
Shawnee Okla

Bolin Oil Co & D H Bolin
1120 Oil & Gas Bldg
Wichita Falls Tex

Tom Bomar Well Serv
Talpa Tex

Boyd & Durst Drlg Contr
Box 329
Alice Tex

E G Bradham
First Natl Bk Bldg
El Dorado Ark

Brannon & Murray Drlg Co
Box 672
Coleman Tex

Brantly Drlg Co Inc
109 Allen Bldg
Midland Tex

Branyan Drlg Co
Box 166
Cushing Okla

C E Brehn
Drawer 618
Mt Vernon Ill

Brewster-Bartle Drlg Co Inc
1912 Esperson Bldg
Houston Tex

Brinkerhoff Drlg Co
870 Denver Club Bldg
Denver 2 Colo

Zach Brooks Drlg Co
Box 31
El Dorado Ark

Brown & Martin Drlg Co
Box 731
Gainesville Tex

Brown & Thorp Drlg Co
Box 1358
McCamey Tex

Brown Drlg Co
1456 E Hill
Long Beach Calif

Harry T Bryant Drlg Co Ltd
3007 Buffalo Dr
Houston 19 Tex

Bryant-Hayward Drlg Co
Box 4627
Oklahoma City Okla

Bueno Drlg Co
425 Continental Oil Bldg
Denver Colo

Buick Drlg Inc
Box 331
St John Kans

Bullard Drlg Co Inc
Melrose Bldg
Houston Tex

A O Bullock Drlg Co
Box 821
Casper Wyo

Burger Drlg Co
Box 327
Coleman Tex

Burnham & Robinson Drlg Co
4045 N Market St
Shreveport La

Butler County Drlg Co
506 Orpheum Bldg
Wichita Kans

Buzzini Drlg Co
541 Milam Bldg
San Antonio 5 Tex

B G Byars Power Drlg Co
318 Citizens Bk Bldg
Tyler Tex

CBS Workover Co
1713 N Esperson Bldg
Houston Tex

C N P Drlg Co
Staley Bldg
Wichita Falls Tex

Cactus Drlg Corp of Tex
Box 348
San Angelo Tex

Calco Drlg Co
1113 Continental Bk Bldg
Ft Worth Tex

Calvert Drlg Inc
204-S Fair St
Olney Ill

Camay Drlg Co
Box 391
Compton Calif

Camay Drlg Co
Rocky Mt Div
Box 1496
Denver Colo

Camden Drlg Co
Sinclair Bldg
Ft Worth Tex

Camdrill International Inc
% Camay Drlg Co
Box 391
Compton Calif

Canadian River Drlg Co
424 Petroleum Bldg
Amarillo Tex

Cannon Drlg Co
209 Windsor Hotel
Abilene Tex

Capitan Drlg Co Inc
Box 671
Odessa Tex

Capitt Drlg Co
814-16 Union Center
Wichita Kans

Frank Caraway Drlg Co
Box 982
San Angelo Tex

Carmack Drlg Co
1008 Mile High Center
Denver Colo

Carpenter-Trant Drlg Co
203 C A Johnson Bldg
Denver Colo

Carter-Jones Drlg Co
Box 1597
Kilgore Tex

Casner & Bentz
Box 666
Oildale Calif

Catline Dodson Co Inc
Box 8503
Oklahoma City Okla

Central Drlg Co
Box 44
Fairfield Ill

Central Drlg Co
704 10th St
Lawrenceville Ill

Chambless-Rosen Drlg Co
Box 4294
Oklahoma City Okla

Chessher Sutton & Davis Drlg Co Inc
366 San Jacinto Bldg
Houston 2 Tex

Chiles Drlg Co
Box 949
Alice Tex

Choate & Hitt
Box 310
Cisco Tex

Dan L Clark Drlg Co
1101 Wilson Bldg
Corpus Christi Tex

Clark Drlg Co
Box 1743
Billings Mont

Clark Fuel Prod Co
Box 473
Mission Tex

R L Bob Clark Drlg Contr
Box 1933
Kermit Tex

Don Clawson
Box 516
Ada Okla

Claypool Drlg Co
St Elmo Ill

Clayton-Dwyer Drlg Co
905 City Natl Bldg
Wichita Falls Tex

Clegg & Hunt
715 Houston Club Bldg
Houston Tex

Coastal Drlg Co
7300 La Hore Rd
Bakersfield Calif

Coastal Marine Drlg & Constr Co
450 Bk of the Southwest Bldg
Houston 2 Tex

Colorado Wyoming Drlg Co
1119 Mile High Center
Denver Colo

Columbia Drlg Co
1207 C & I Life Bldg
Houston 2 Tex

Comet Drlg Co
Box 1143 OCS
Lafayette La

Compagnia Industries Metanifere E Affine
(Rome Italy)
Box 2012
Tyler Tex

Conrey Drlg Co
328 E Broadway
Centralia Ill

Continental Drlg Co Inc
413 Shell Bldg
New Orleans La

Continental Shelf Drlg Co
223 Internatl Trade Mart Bldg
New Orleans La

Coon-Murphy Drlg Co
3272 Westheimer
Houston Tex

Cooper Drlg Co
902 Staley Bldg
Wichita Falls Tex

R A Cooper Drlg Co
711 Hulman Bldg
Evansville Ind

Coral Drlg Co
6100 Camp Bowie
Ft Worth Tex

J M Corbett
6282 E Marshall
Tulsa Okla

Coroco Drlg Co
2807 Mercantile Bk Bldg
Dallas Tex

Cortez Drlg Co
1700 Broadway
Denver Colo

Crawford Drlg Co
Box 622
Shreveport La

Criswell Drlg Co
Box 253
Arkansas City Kans

Cron & Gracey Corp
1100 Houston Club Bldg
Houston Tex

Crowe Drlg Co
211 Perkins Bldg
Duncan Okla

Crown Rigs Inc
2107 Bk of the Southwest Bldg
Houston Tex

Sam E Crump Drlg Co
408 Union Bldg
Midland Tex

Harry L Cullet
Purefoy Hotel
Talladega Ala

Cummins Drlg Co
Altamont Ill

W C Curry Drlg Co Inc
Box 1528
Longview Tex

Curtis & Lomax Drlg Co
Box 584
Midland Tex

D & M Drlg Co Inc
Box 247
Great Bend Kans

Clark Dale Drlg Co Inc
Box 788
San Angelo Tex

Danforth Drlg Co
418 Kennedy Bldg
Tulsa Okla

R A Davenport Drlg Contr
211 Perkins Bldg
Duncan Okla

Davidson Drlg Co Inc
1004 Continental Life Bldg
Ft Worth Tex

Edgar Davis Drlg Co
717 Citizens Bk Bldg
Abilene Tex

Harvey Davis & Robt H Thompson Co
1731 28th St
Bakersfield Calif

Davon Drlg Co
Box 1586
Oklahoma City Okla

Dearing Inc
Box 655
Dallas Tex

Deepwater Expl Co
1109 Tex Natl Bk Bldg
Houston Tex

Delaney Drlg Co
Box 881
Ada Okla

M J Delaney Co
512 Continental Bldg
Dallas 1 Tex

Delison Drlg Co
U S Natl Bk Bldg
Denver Colo

Del Mar Drlg Co
409 Oil Industries Bldg
Corpus Christi Tex

Delta Drlg Co
Box 2012
Tyler Tex

Delta Marine Drlg
Box 2012
Tyler Tex

The Denver Co
1904 Great Plains Life Bldg
Lubbock Tex

Denver Drlg Corp
Box 669
Odessa Tex

W L Dillier
Box 341
Casey Ill

Dillingham Drlg Co
Box 1346
Alice Tex

Dixilyn Drlg Corp
Box 3427
Odessa Tex

Dixon Drlg Co
338 Petroleum Bldg
Abilene Tex

Doak Drlg Co
Box 1108
Bristow Okla

Doc Drlg Corp

Blackie Drlg Co Inc

Neva-Andre Drlg Corp
210 Willow St
Franklin La

Donnell Drlg Co
607 Texas Bk Bldg
Dallas Tex

Douglas Drlg Co
Box 748
Oildale Calif

Drillers Inc
2005 Adolphus Tower
Dallas Tex

Drlg & Prod Co
2907 L St
Bakersfield Calif

Drill Well Oil Co
1502 8th St
Wichita Falls Tex

Dual Drlg Co
606 City Natl Bk Bldg
Wichita Falls Tex

Dublin-Kiel
1126 Oil and Gas Bldg
Wichita Falls Tex

Dudley & Heath Drlg Co
Box 428
Stillwater Okla

B A Duffy Drlg Co
Rm 100 Crescendo Bldg
Abilene Tex

N V Duncan Drlg Co
303 Oil and Gas Bldg
Oklahoma City Okla

Dunnam & Wyant Drlg Co
816 N Jordan
Liberal Kans

Durham Drlg Co Inc
Box 204
Midland Tex

Dyer Drlg Co
Box 338
Casper Wyo

E & H Drlg Co
Box 1058
Graham Tex

E & M Drlg Co
Collinsville Okla

Eagle Drlg & Developing Co
Box 89
Natchez Miss

Eakle & Holder Drlg Co
116 Mulberry St
Evansville Ind

Eastern Drlg Inc
Box 291
Carmi Ill

Eastland Oil Co
806 Continental Life Bldg
Ft Worth Tex

Edwards & Bissett Inc
Box 298
Almeda Tex

Edwards Drlg Co
Box 1140
Graham Tex

Harry L Edwards Drlg Co
Box 6825
Houston Tex

A W Eggleston Inc
Box 425
Crowley La

Eilers Drlg Co
Box 169
New Iberia La

Ellis & Gray
1536 Austin St
Colorado City Tex

Ellis Drlg Corp
1536 Austin
Colorado City Tex

Empire Drlg Co
1507 Mercantile Bk Bldg
Dallas Tex

Empire Drlg Co
400 Brown Bldg
Wichita Kans

Empire States Drlg Corp
1020 Simms Bldg
Albuquerque N M

Enterprise Oil Co
7440 La Hore Rd
Bakersfield Calif

Ewing Drlg Co
Box 807
Breckenridge Tex

Exeter Drlg Co
103 Central Bldg
Midland Tex

Exploration Drlg Co
607 Natl Bk of Tulsa Bldg
Tulsa Okla

Fain-Porter Drlg Corp
2410 First Natl Bldg
Oklahoma City Okla

Fairman Drlg Co
Hammersley Fork Pa

Falcon Seaboard Drlg Co
Pan American Bldg
Tulsa Okla

Felderhoff Bros Drlg Co
Box 87
Muenster Tex

Ferbanta Drlg Co
Box 107
Carmi Ill
Box 172
Perry Okla

Fesco Inc
920 First Natl Bk Bldg
Tulsa Okla

Field Drlg Co
1900 Milam Bldg
San Antonio Tex

Jim Fish Drlg Co
Box 655
Iowa Park Tex

Fitzpatrick Drlg Co
803 Wilson Tower
Corpus Christi Tex

Fleeger Drlg Inc
271 Meadows Bldg
Dallas 6 Tex

J B Fletcher Drlg Co
306 Ricou-Brewster Bldg
Shreveport La

Flournoy-Haston Drlg Co Inc
1005 Davis
Ardmore Okla

Folk Drlg Co
614 Main
Yukon Okla

Foree Drlg Co
602 First Natl Bk Bldg
Dallas Tex

Fortenbery Drlg Co Inc
Box 273
Natchez Miss

Fortune Drlg Corp
Petroleum Bldg
San Angelo Tex

C J Foster Drlg Co Inc
Box 657
Richmond Tex

Foster Drlg Co
Box 751
Cushing Okla

4-J Drlg and Well Serv Co
Box 471
Drumright Okla

Armstrong Fowler Inc
929 Oleander
Bakersfield Calif

J O Fox & Son
620 F & M Bk Bldg
Abilene Tex

Frank Frawley Drlg Co
823 S Detroit
Tulsa 3 Okla

Lloyd R French Co
506 V & J Tower
Midland Tex

Frio Drlg Inc
506 Driscoll Bldg
Corpus Christi Tex

Frisbie Drlg Inc
402 Pan American Bldg
Tulsa 3 Okla

Frizzell Drlg Co
108 NW 2nd St
Oklahoma City Okla

Gabbert-Jones Drlg Co
514 Orpheum Bldg
Wichita Kans

C S Garber & Sons Inc
Boyertown Pa

Gardner Bros Drlg Co
1708 Davis Bldg
Dallas Tex

Buster Gardner Drlg Co Inc
Box 281
New Iberia La

Garr-Woolley Oil Co
901 Cravens Bldg
Oklahoma City Okla

Garvey Drlg Co
Route 2
Great Bend Kans

Gary Drlg Co
Box 58
Oil City La

General Drlg Co
Colcord Bldg
Oklahoma City Okla

General Geophysical Co
750 Houston Club Bldg
Houston 2 Tex

General Well Drlg Co
Box 1315
Alice Tex

Gibson Drlg Co
Box 1540
Kilgore Tex

Lee Gibson Oil Co
Box 407
Riverdale Calif

Gilger Drlg Co
831 N Esperson Bldg
Houston 2 Tex

Glenn Gillespie & Sons
Box 907
Cushing Okla

Willard Gladson & Odstrcil Bros Drlg Co
2705 W 35th St
Snyder Tex

C G Glasscock Drlg Co
1601 Wilson Tower
Corpus Christi Tex

Glendale Drlg Co
906 Hales Bldg
Oklahoma City Okla

Glenn Drlg Co
38 Kennedy Bldg
Tulsa Okla

F E Gober Drlg Co
3032 Cherry Ave
Long Beach Calif

Golden Meadow Well Serv
616 Carondelet Bldg
New Orleans La

Gold-Mar Drlg Co
Box 732
Dewar Okla

Goldsmith Drlg Co
Box 750
Duncan Okla

Gordon Drlg Co
Box 15
Mt Pleasant Mich

Gore Drlg Co
Box 515
Albany Tex

T V Gorman
621 Staley Bldg
Wichita Falls Tex

Gracey-Hellums Corp
410 S Coast Bldg
Houston 2 Tex

Burdette Graham
804 Driscoll Bldg
Corpus Christi Tex

Graham-Michaelis Oil Co
211 N Broadway
Wichita 7 Kans

Graves Drlg Co
Box 583
Ardmore Okla

Graytex Drlg Co
300 Oil & Gas Bldg
Wichita Falls Tex

Great Western Drlg Co
Box 1659
Midland Tex

Green & Dreblow Drlg Co
Box 1057
Bakersfield Calif

Green & Heiser Drlg Co
Box 3098
Bakersfield Calif

Greenland Drlg
4722 Broadway
Kansas City 12 Mo

Greenwood Petroleum Management Inc
Eureka Kans

Greyhound Drlg Co Inc
Box 4334
Shreveport La

Grey Wolf Drlg Co
1506 Bk of the Southwest
Houston Tex

Guadalupe Drlg Co
2505 Princeton Ave
Midland Tex

Roy Guffey Drlg Co
5543 Yale Blvd
Dallas 6 Tex

Gulf Coast Drlg & Expl Inc
Box 2367 Choctaw Sta
Laurel Miss

Henry Gwaltney Drlg Co
Box 289
Washington Ind

Hack Drlg Co
Box 1636
Abilene Tex

John S Hagestad Drlg Co
3224 Gulf St
Bakersfield Calif

Halbert Drlg Co
3414 Bain Pl
Tyler Tex

Hale Bros Drlg Co
315-B City Natl Bldg
Wichita Falls Tex

Clyde Hall Drlg Co Inc
Box 107 Sta B
Bakersfield Calif

O E Hall Drlg Co
2008 Continental Natl Bk Bldg
Ft Worth Tex

Hamilton-Powell Drlg Co Inc
1220 Hamilton Bldg
Wichita Falls Tex

Hamman Oil & Ref Co
Box 13028
Houston 19 Tex

Paul Hamner Drlg Co
Box 861
Duncan Okla

Harkins & Co
Box 1490
Alice Tex

Dave Harlin Drlg Co
2605 Avenue R
Snyder Tex

Harms-Burt Drlg Co
510 Petroleum Bldg
Wichita Kans

Harold Drlg Co Inc
1633 Walnut
Abilene Tex

Harrell Drlg Co
611 Melrose Bldg
Houston Tex

Harris Drlg Co
Box 699
Grayville Ill

John W Harris Drlg Co
525 Wichita Natl Bk Bldg
Wichita Falls Tex

C H Hartman
206 Security Bldg
Sapulpa Okla

Harvey Drlg Co
Box 418
Wichita Falls Tex

Harvey Drlg Co Inc
Box 94
Harvey La

John Haseman Inc
419 Wilson Bldg
Corpus Christi Tex

J W Hastings Drlg Co
Wichita Natl Bk Bldg
Wichita Falls Tex

Hawkins-Wilkins Prod Co
373 San Jacinto Bldg
Houston Tex

Win Hawkins Drlg Co
373 San Jacinto Bldg
Houston 2 Tex

Hayes & Sprague Inc
463-466 Gen Pet Bldg
Los Angeles Calif

Hayward Drlg Co
Box 295
Enid Okla

John Heard & Co Inc
624 S Cheyenne
Tulsa Okla

Helmerich & Payne Inc
First Natl Bldg
Tulsa Okla

Henderson Drlg Corp
N Esperson Bldg
Houston Tex

Henson Drlg Co
Box 2192
Abilene Tex

The Herb Expl Co
342 Lexington Ave
Abilene Tex

Herndon Drlg Co
Drawer 489
Tulsa Okla

Maxwell Herring Drlg Corp
Box 1122
Kilgore Tex

B M Hester
Box 2588
Wichita Falls Tex

Hewgley Drlg Co
704 Wilco Bldg
Midland Tex

Hewit-Gulick Drlg Co
240 Silver State Bldg
Denver Colo

Highland Drlg Co
Box 671
Odessa Tex

Highland Oil
Box 263
Jasper Ind

Hilburn Industries Inc
Ricou-Brewster Bldg
Shreveport La

Hill Drlg Co
Box 532
Conroe Tex

J E Hillier
Box 67
Pleasanton Tex

Hills & Hills Drlg Co
Box 2158
Pampa Tex

C F Hills Drlg Co
Box 2158
Pampa Tex

Hissom Drlg Co
1327 Wilco Bldg
Midland Tex

Holliman Drlg Co
712 Fidelity Union Life Bldg
Dallas Tex

Holm Drlg Co
Box 7246
Tulsa Okla

Holmes Drlg Co
1045 San Jacinto Bldg
Houston Tex

Holt Brothers Drlg Co
Box 236
Pampa Tex

W C Holt Drlg Co Inc
909 Enterprise Bldg
Tulsa Okla

Hondo Drlg Co
Box 116
Midland Tex

R L Horn & Son Drlg Co
Pawnee Okla

Hose-Austin Drlg Corp
Box 1067
Casper Wyo

Houchins Drlg Co
Box 388
Mt Carmel Ill

Housh Drlg Co
586 Gulf Bldg Addn
Houston 2 Tex

Houston Oil Well Serv Co
1706 C & I Life Bldg
Houston 2 Tex

H H Howell
801 Milam Bldg
San Antonio Tex

Hull Oil Co
214 Panhandle Bldg
Wichita Falls Tex

Hupp & Hume
Box 616
Owensboro Ky

I J Huval Well Serv Co
Box 261
Pampa Tex

Floyd R Hyer
1230 E 8 St
Okmulgee Okla

I R T Drlg & Prod Co
1576 Carol Lane
Wichita Falls Tex

Index Drlg Co
Box 918
Laurel Miss

Indian Drlg Co
Box 42
Tulsa Okla

Donald T Ingling
623 First Natl Bldg
Wichita 2 Kans

International Drlg Co
3040 Cherry Ave
Long Beach 7 Calif

Irish Drlg Co Inc
Box 225
Eastland Tex

Iron Drlg Co
1206 Philtower Bldg
Tulsa 3 Okla

Isern Drlg Co
Box 45
Ellinwood Kans

Ivy Drlg Co
1705 Burton Way
Bakersfield Calif

J & C Drlg Co
Box 552
Refugio Tex

J & J Drlg Co
Box 150
Holdenville Okla

J & L Drlg Co Ltd
2005 Adolphus Tower Bldg
Dallas Tex

J E B Drlg Co
750 W 5th St
Ft Worth Tex

J M C Drlg Interests
6282 E Marshall
Tulsa Okla

S W Jack Drlg Co
Avonmore Pa

Charles M Jameson
Box 532
Vernal Utah

Jennings Drlg Co
612 City Natl Bk Bldg
Wichita Falls Tex

Jet Drlg Co Inc
304 California Bldg
Denver 2 Colo
Johan Drlg Co
711 Fair Bldg
Ft Worth Tex
Johnson-Bates Drlg Co
Box 425
Konawa Okla
Johnson-Gadbois Drlg Co
Box 9338
Ft Worth Tex
Johnson Drlg & Serv Co
Box 3
Magnolia Ark
Fred Johnson Drlg Co
2790 Cherry Ave
Long Beach Calif
S D Johnson
304 Mile High Center
Denver Colo
Buck Jones Drlg Co
Box 1085
McCamey Tex
J E Jones Drlg Co
Box 2218
Midland Tex
Jones Well Serv Co
Box 609
Abilene Tex
Justiss-Mears Oil Co
Box 396
Jena La
K & S Drlg Co
First Natl Bldg
Bartlesville Okla
Karper & Glass
Box 149
Graham Tex
Keating Drlg Co
510 Natl Bk Tul Bldg
Tulsa Okla
Kee & Simpson Drlg Co
417 S Hill St
Los Angeles 13 Calif
K L Kellogg & Sons
Box 510
Compton Calif
Kelly Drlg Co
Box 1126
Houma La
Kendall-Davis Drlg Co Inc
201 S E 1st St
Evansville Ind
Kent & Preston
425 Sayles Blvd
Abilene Texas
Kent Drlg Co
Box 2555
Salt Lake City Utah
Kerr-McGee Oil Industries Inc
Kerr-McGee Bldg
Oklahoma City Okla
Kersey & Co
Box 305
Artesia N Mex
Keyes Drlg Co
Box 1108
Roswell N Mex
Carl B King Drlg Co of Tex
Box 270
Midland Tex
Kingery Drlg Co Inc
Box 97
Saint Jo Tex
King-Phillips Inc
1109 Continental Natl Bk Bldg
Ft Worth Tex
Kirby Oil Ltd
Box 114
Billings Mont
Hugh Kirkpatrick Inc
Box 312
Mission Tex
Kirkpatrick Oil Co
1300 N Broadway
Okla City Okla
A F Knappenberger and K & H Drlg Co
427 Elm St
Graham Tex

Donald P Knierim
Box 277
Casey Ill
Knight Drlg Co
Box 1332
Bakersfield Calif
Kuehn & Roberts
508 Mims Bldg
Abilene Tex
A J Kuenstler Drlg Co
Box 1374
Alice Tex
Kullberg & Otthouse Inc
Cut Bank Mont
Ralph G Ladd
Box 5
Haskell Okla
Lake Drlg Co
1417 Church
Beaumont Tex
La Mance Drlg Co
Box 2686
Midland Tex
Lamar Drlg Corp
Box 4128 Centenary Sta
Shreveport La
Larco Drlg Co
Box 3499
Jackson Miss
Howard C Lasiter Drlg Co
Box 172
Grandfalls Tex
Lauderdale & Straughan Drlg Co
328 F & M Bk Bldg
Abilene Tex
Lauderdale Drlg Inc
Box 3
Metropolis Ill
Laughlin-Porter Drlg Co Inc
Petroleum Life Bldg Rm 9
Midland Tex
J W Lawrence
Box 942
Conrad Mont
Joe Lawrence Drlg Co
Box 1021
Ada Okla
Layton and Newell Drlg Co
1321 Oil and Gas Bldg
Ft Worth Tex
Leatherwood Drlg Co
Box 925
Jacksboro Tex
Lee Drlg Co
1007 Philtower Bldg
Tulsa Okla
Lemar Well Serv Corp
Box 407
Riverside Calif
D B Lesh Drlg Co
Box 505
Mattoon Ill
Lewis Bros Inc
320 Mile High Center
Denver 2 Colo
Lewis Drlg Co
915 Union Center
Wichita Kans
Liberty Drlg Corp
Box 14308
Houston Tex
Ted Lindsay Drlg Contr
Box 190
Mt Vernon Ill
M M Lindsey Drlg Co
4748 Airline Hwy
Baton Rouge La
H J Lininger
Box 37
Upper Sandusky Ohio
Lin-Mour Drlg Co
Oil and Gas Bldg
Wichita Falls Tex
Livermore Drlg Co
406 Lubbock Natl Bk Bldg
Lubbock Tex
Llano Drlg Co
301 Y & J Tower Bldg
Midland Tex

Loffland Bros Co
Box 1649
Tulsa Okla
Lofton Drlg Co
707 Oil and Gas Bldg
Wichita Falls Tex
Lohmann-Johnson Drlg Co Inc
320 Indiana Bk Bldg
Evansville Ind
Lomax Drlg Co
Box 584
Midland Tex
Charles E Long Jr Inc
Box 961
Midland Tex
Longhorn Drlg Corp
Box 546
Three Rivers Tex
Low Drlg Co
Box 1112
Cisco Tex
Lowe Drlg Co
Box 832
Midland Tex
Lusk Drlg Co
No. 11 U-Totem Lane
Houston 24 Tex
Lynn Drlg Co
1403 Natl Bk Tul Bldg
Tulsa Okla
H B Lynn Drlg Corp
Box 1085
Farmington N Mex
M & J Inc
3612 W Wall
Midland Tex
M-H-O Drlg Co
Box 297
Cut Bank Mont
MIM Drlg Corp
Majestic Bldg
San Antonio Tex
Mac Drlg Co
Box 2972
Houston Tex
Macrate Prod Co
3341 Cherry Ave
Long Beach 7 Calif
Mallard Drlg Co
1016 Union Natl Bk Bldg
Wichita Kans
Mallonee Drlg Co Inc
Union Center
Wichita Kans
R L Manning Co
318 Continental Oil Bldg
Denver Colo
Marcum Drlg Co
Box 761
Ada Okla
Mardale Drlg Co
Box 107
Duncan Okla
Marex Inc
112½ Del Laquara St
Santa Barbara Calif
Marhill Oil & Gas Co Inc
523 Frederica St
Owensboro Ky
Maritzky & Bibby
Box 509
Homer La
Martin & Holmes Oil Well Serv Co
4730 Ayers
Corpus Christi Tex
Maxwell Drlg Co
Box 846
Coleman Tex
M Mazzarino
Staunton Ill
McAlester Fuel Co
Box 210
Magnolia Ark
Gabe McCall Drlg Co
Box 2068
Casper Wyo
McCalman Drlg Co Inc
Box 602
Homer La

McClure Oil Co
Box 147
Alma Mich
McCutchen & Graham
409 Oil and Gas Bldg
Wichita Falls Tex
Gene McCutchin
Box 1585
Dallas Tex
McDaniel & Beecherl Drlg Co
607 Davis Bldg
Dallas Tex
McDaniel Drlg Co
205 C A Johnson Bldg
Denver 2 Colo
B L McFarland Drlg Corp
3612 W Wall
Midland Tex
B L McFarland Inc
3612 W Wall
Midland Tex
W H McGarr Industries
Box 826
Coleman Tex
C W McGill Drlg Co
O'Michael Bldg
Odessa Tex
J R McGill
509 Amarillo Bldg
Amarillo Tex
McGoldrick & Watson Drlg Co
213 Beck Bldg
Shreveport La
McQueen & Stout Drlg Co
1113 Ft Worth Natl Bk Bldg
Ft Worth 2 Tex
Meadows & Walker Drlg Co
500 San Jacinto Bldg
Houston 2 Tex
Melco Drlg Co
Box 1360
Seminole Okla
Mercury Drlg Corp
1205 Beck Bldg
Shreveport La
Meredith & Co
Bk of the Southwest Bldg
Houston Tex
Meredith Drlg Co
419 City Natl Bldg
Wichita Falls Tex
Ward S Merrick
Box 971
Ardmore Okla
Mesker Drlg Co
1129 E 15th St
Tulsa Okla
Midland Drlg Co
410 W Ohio
Midland Tex
Midwestern Drillers Inc
1206 Mid-Continent Bldg
Tulsa 3 Okla
Milam Drlg Co
1814 Alamo Natl Bldg
San Antonio Tex
J Conley Miles Drlg Co
Box 1791
Abilene Tex
Milestone Drlg Co
Box 2745
Midland Tex
Milhoan Drlg Co
Box 948
Tulsa Okla
Miller & York
Box 936
Bakersfield Calif
Miller Bros & Bowling
Box 611
Alice Tex
Miller Drlg Co
Box 24
Jackson Miss
Gene Miller Inc
Box 238
Lawrenceville Ill
J E Miller Drlg Contr
Box 1581
Abilene Tex
Miracle-Fifer Drlg Co
1636 Welton St
Denver 2 Colo
J S Montgomery
103 NW 44th St
Oklahoma City Okla
Moore & Moore Drlg Co
Box 29
Abilene Tex
Lamar H Moore Drlg Co
Box 29
Abilene Tex
Moran Bros Inc
1200 Oil and Gas Bldg
Wichita Falls Tex
E W Moran Drlg Co
500 First Natl Bk Bldg
Wichita Falls Tex
Moran Oil Prod & Drlg Corp
Box 1718
Hobbs N Mex
Dave Morgan Drlg Co
Box 820
Blackwell Okla
Morris & Hamilton Drlg Co Inc
1521 Commerce Bldg
Houston 2 Tex
Pete Morris Drlg Co
Box 733
Ada Okla
Morrison Drlg Co Inc
Box 583
Casper Wyo
Mountain States Drlg Co Inc
622 Patterson Bldg
Denver Colo
Moutray Drlg Co Inc
Box 1904
Abilene Tex
R V Muckelroy & Son
Adams Bldg
Lockhart Tex
Musgrove Petroleum Corp
801 Union Center
Wichita Kans
Muskegon Development Co
432 Lyman Bldg
Muskegon Mich
Mustang Drlg Corp
1201 Peoples Bk Bldg
Tyler Tex
Muzny Drlg Co
Box 745
Prague Okla
Neal Drlg Co
Box 423
Victoria Tex
Nebraska Drillers Inc
Box 595
Grand Island Neb
Needham Drlg Co
Box 1285
Artesia N Mex
Nemaha Oil Co
Mercantile Bk Bldg
Dallas Tex
Nicklos Drlg Co
518 City Natl Bk Bldg
Houston Tex
Nichols Drlg Co
Box 1032
Duncan Okla
The Noah Petroleum Co
Box 192
Albion Ill
George Noland Drlg Co Inc
823 S Detroit Ave
Tulsa Okla
Norman Oil Corp
1141 Butternut St
Abilene Tex
Norton Drlg Co
542 Natl Bk of Commerce Bldg
New Orleans 12 La
William A Norton
6516 NW Grand Blvd
Oklahoma City Okla
Norwood Drlg Co
700 Wichita Natl Bk Bldg
Wichita Falls Tex
The Novak Drlg Co
Box 2147
Tulsa Okla
Nuckolls-Bell Drlg Co
First Natl Bldg
Oklahoma City 2 Okla
Nye & Snell Drlg Co
208 Patterson Bldg
Denver Colo
Ocean Drlg & Expl Co
918 Carondelet Bldg
New Orleans La
The Offshore Co
Box 1908-1268
Baton Rouge La
The Oil Corp
3105 Leopard St
Corpus Christi Tex
Bob Olds Drlg Co
Box 113
Casper Wyo
Olds Oil & Chem Corp
Box 72
Mt Carmel Ill
O'Neal Drlg Co
1314 Oil and Gas Bldg
Ft Worth Tex
Oney Drlg Co
Box 425
Graham Tex
Orm Drlg Co
421 M & P Bk Bldg
Sherman Tex
O'Rourke-McGirl Drlg Corp
632 Natl Bk Tul Bldg
Tulsa Okla
The Overby Drlg Co
Box 248
Nowata Okla
Oxford & Stassney Drlg Co
Box 307
Albany Tex
Paco Petroleum Corp
Box 347
Mt Carmel Ill
Paine Drlg Co
301 InsurOMedic Bldg
Dallas Tex
Pan-Tex Drlg Co
316 Henderson Blvd
Kilgore Tex
Parker Drlg Co
418 Natl Bk Tul Bldg
Tulsa Okla
Patton Drlg Co Inc
Orpheum Bldg
Wichita Kan
Noel Pautsky
Oil and Gas Bldg
Wichita Falls Tex
Payne Bros Drlg Co
1411 10th St
Lawrenceville Ill
Peak Drlg Co Inc
1019 Central Bldg
Wichita Kans
Pegg Bros Drlg Co
1204 Natl Bk of Commerce Bldg
San Antonio Tex
Penrod Drlg Co
418 Market St
Shreveport La
Pep Drlg Co
1008½ Main St
Mt Vernon Ill
Perkins Bros Drlg Co
Box 1232
Duncan Okla
Perrine & Perrine Drlg Contr
Box 87
Salem Ill
Petersen Drlg Co
306 Fairfield Bldg
Shreveport La
Petro Drlg Co Inc
Box 339
Mt Vernon Ill
Petrolex Inc
361 Palmtag
Hollister Calif

H F Pettigrew
836 Republic Natl Bk Bldg
Dallas Tex
R P Phillips
Box 246
Lafayette La
Pool & Gerlich Drlg Co
Box 1940
San Angelo Tex
Fred Pool Drlg Contr
Box 172
Abilene Tex
Poteet Wyser & Eckles Inc
Box 508
Holdenville Okla
Powell Drlg Co
412 Union Center Bldg
Wichita Kans
Graham Powell Drlg Co
129 N Sycamore St
Centralia Ill
The Power Rig Drlg Co
Box 1436 OCS
Lafayette La
Prairie Drlg Co
Box 2068
Casper Wyo
Prime Drlg Co
814-16 Union Center
Wichita Kans
Princeton Mining Co
111 N 7th St
Terre Haute Ind
Progressive Drlg Co Inc
Box 27
Newcastle Wyo
Pyburn Drlg Co
Box 4276
Shreveport La
Pyramid Drlg Co
Box 1047
Monahans Tex
R-G Drlg Co
403 City Natl Bk Bldg
Wichita Falls Tex
R W I T Drlg Co
506 Diamond St
Holdenville Okla
Frank Raiborn Drlg Co
35 Garden Rd
San Angelo Tex
Ramey Well Serv
212 Hamilton Bldg
Wichita Falls Tex
G H Ray Well Serv
Box 68
Cement Okla
Jack and H P Read
Box 212
Scottsville Ky
Reading & Bates Offshore Drlg Co
1502 Philtower Bldg
Tulsa Okla
Reaves Drlg Co Inc
Box 32
Cushing Okla
Rebstock & Reeves Drlg Co
514 Calif Bldg
New Orleans La
Red River Drlg Co
Baker Bldg
Breckenridge Tex
Reed Drlg Co
1209 Atlas Bldg
Tulsa Okla
Gene Reid Drlg Inc
3505 Pierce Rd
Bakersfield Calif
Reserve Drlg Co Inc
Box 1612
Casper Wyo
Reserve Drlg Co Inc
625 Union Center
Wichita 2 Kans
Rheay & Reynolds Drlg Co
402-406 Petroleum Bldg
Abilene Tex
Rhodes & Hicks Drlg Corp
Box 1395
Alice Tex
Rhodes Drlg Co
Box 239
Abilene Tex
Riceland Corp
Box 747
Dallas Tex
Marvin S Ridgeway
Box 943
Beeville Tex
Riley & Gammon
509 N Railroad St
Madisonville Ky
Rimrock Tidelands Inc
1315 Gravier St
New Orleans La
The R W Rine Drlg Co
420 Union Center
Wichita Kans
C M Roberson Drlg Co
418 Market St
Shreveport La
Rocket Drlg Co
2099 E 27th St
Long Beach Calif
Rocket Drlg Co Inc
352 N Broadway
Wichita Kans
Rocky Mountain Drlg Co
550 S Flower St
Los Angeles Calif
Roden & McRae Drlg Corp
Box 2286
Casper Wyo
R Benton Ross Inc
620 Wichita Natl Bk Bldg
Wichita Falls Tex
Don M Rounds Drlg Co Inc
620 Colorado Bldg
Denver Colo
Rowan Drlg Co Inc
Drawer 12247
Ft Worth 16 Tex
B L Rucker Drlg Co
Box 127
Mt Vernon Ill
Rud Drlg Co
Box 35
Coweta Okla
J W Rudy
Box 684
Clay City Ill
Ruhl Drlg Co Inc
1621 Bk of Southwest Bldg
Houston 2 Tex
Rupp-Ferguson Oil Co
522 Union Center Bldg
Wichita Kans
Russan Drlg Co
Box 861
Midland Tex
Russell & Russell Drlg & Prod
621 Lindsay St
Gainesville Tex
Sabre Drlg Co
222 Hughes Bldg
Cushing Okla
Salt Dome Prod Co
737 Texas Natl Bk Bldg
Houston 2 Tex
Gordon O Sams Drlg Co
Box 126
Tulsa Okla
St John Drlg Co
Box 639
Ballinger Tex
San Joaquin Drlg Co Inc
417 S Hill St
Los Angeles 13 Calif
Santa Fe Drlg Co
Box 310
Whittier Calif
Santa Maria Drlg Corp
2875 Cherry Ave
Long Beach 6 Calif
Santa Rosa Drlg Co
Box 633
Apple Valley Calif
Saunders Drlg Inc
Box 5383
Sonora Tex
Schafer Drlg Co
2400 Liberty Bk Bldg
Oklahoma City Okla
J B Schick Drlg Co
510 Petroleum Bldg
Abilene Tex
A L Schlaikjer
Box 761
Newcastle Wyo
Schoenfeld-Hunter-Kitch Drlg Co
Box 588
Tulsa 1 Okla
Schulz & Brannan Drlg Co
621 Staley Bldg
Wichita Falls Tex
A B See Drlg Co Inc
206 Petroleum Bldg
Abilene Tex
Paul Septer Drlg Co
521-22 Union Natl Bk Bldg
Wichita Kans
Seran & Howard Drlg Co
Box 110
Okemah Okla
Service Drlg Co
515 Kennedy Bldg
Tulsa Okla
Severns Drlg Co Ltd
639 S Spring St Suite 1119
Los Angeles Calif
Harold Shappell Drlg Co
510 City Natl Bldg
Wichita Falls Tex
Sharp Drlg Co
Box 1271
Midland Tex
Sheets & Walton Drlg Co
Box 152
Breckenridge Tex
Shelley-Miller Drlg Co
115 N Broadway
Wichita Kans
Sherin Drlg Co Inc
First Natl Bldg
Oklahoma City Okla
Shields Drlg Co Inc
Shields Bdlg
Russell Kans
Shields Oil Producers
Shields Bldg
Russell Kans
Shoreline Drlg Co Inc
1203 Beck Bldg
Shreveport La
Shulman Bros
Box 191
Vandalia Ill
Signal Oilfield Serv
203 Mayo Bldg
Tulsa Okla
Skinner & McDougal Drlg Co
Box 8774
Oklahoma City Okla
Skipper Drlg Co
Box 511
Cushing Okla
Don Slape Drlg Co
Box 432
Olney Ill
Smith & Breyer
Suite 154 Meadows Bldg
Dallas 6 Tex
B B Smith Inc
Box 2876
Midland Tex
Sojourner Drlg Corp
Box 686
Abilene Tex
Sonic Drlg & Equip Co Inc
Box 861
Midland Tex
Sooner Drlg Co
412 Federal Natl Bk Bldg
Shawnee Okla
Southeastern Drlg Corp
901 Employers Ins Bldg
Dallas Tex
Southern Drlg Co
13th & San Fernando Rd
Newhall Calif

Southern Six Drlg Co Inc
Box 369
Opelousas La
Southland Drlg Co
338 Milam Bldg
San Antonio Tex
South States Drlg Co
Box 2347
Longview Tex
J D Sprecher
Box 299
Casper Wyo
H J Steward
Box 1031
Taylor Tex
Stice Drlg Co
Box 678
Beeville Tex
Stickle Drlg Co
920 First Natl Bk Bldg
Tulsa Okla
Jack L Story
Box 1073
Dallas Tex
Stouder Drlg Co
208 SE Riverside Dr
Evansville Ind
Strait Drlg Inc
Box 90
Eldorado Kans
C W Strotman Drlg Co
620 S 30th St
Mattoon Ill
Summit Drlg Corp
414 Atlas Life Bldg
Tulsa Okla
The Sun Drlg Co
417 S Hill St
Los Angeles 13 Calif
Sun-Marine Drlg Corp
(Offshore Constr Inc)
417 S Hill St
Los Angeles Calif
Sunnyland Contracting Co Inc
Box 388
Rayne La
Sutton Drlg Co
900 NE Military Dr
San Antonio Tex
Swett Bros Drlg Co
Box 331
Bakersfield Calif
Symons Drlg Co
Box 546
Houston Tex
Target Drlg Corp
710 Enterprise Bldg
Tulsa Okla
Taylor Expl Co Inc
2118 Welch Ave
Houston Tex
W P Taylor Drlg Co
1429 Bk of the Southwest
Houston Tex
Tennant Drlg Co
Rivoli Bldg
Blackwell Okla
Terminal Drlg & Prod Co
1240 Blinn Ave
Wilmington Calif
Texoma Drlg Co Inc
1200 Staley Bldg
Wichita Falls Tex
Tex-Mex Drlg
1211 Fidelity Union Life Bldg
Dallas Tex
Thomas & Billups Drlg
809 Citizens Bk Bldg
Abilene Tex
A W Thompson Inc
Box 2524
Houston Tex
Thompson Drlg Co
Box 577
Comanche Okla
Tibbitts Drlg Co
226 Oil and Gas Bldg
Wichita Falls Tex
O C (Tut) Tilley
Box 815
Wewoka Okla
Tolson Drlg Co
213 Triangle Bldg
Pawhuska Okla
Trachta Drlg Co
Box 67
Muenster Tex
Transit Corp
1516 Liberty Bk Bldg
Oklahoma City Okla
Trant Drlg Co
Peoples Bk Bldg
Tyler Tex
Travis Drillers Inc
Box 1097
Austin Tex
Treasure State Drlg Co
Box 1712
Great Falls Mont
Triad Drlg Co
120 Featherston Bldg
Wichita Falls Tex
Tri-County Expl Co Inc
412 Peoples Bk Bldg
Indianapolis 4 Ind
Trimble Drlg Co Inc
Box 459
Magnolia Ark
Trio Drlg Co
3013 Nussbaumer
Dallas 26 Tex
Tri-Service Drlg Co
Box 1785
Midland Tex
Triton Drlg Co Inc
Box 13221
Houston Tex
Troop Drlg Co
Box 145
St Elmo Ill
Troup & Suttles Inc
506 Diamond
Holdenville Okla
True Drlg Co
Box 1612
Casper Wyo
Turnbull & Zoch Drlg Co
Box 2248
Corpus Christi Tex
Twinoak Drlg Co
210 S Morton
Okmulgee Okla
Two R Drlg Co Inc
712 South St
Houma La
Tyco Drlg Corp
Box 818
Shawnee Okla
U & E Drlg Co
Box 323
Sullivan Ind
Rip C Underwood
553 First Natl Bk Bldg
Amarillo Tex
Unit Drlg Co
Box 599
Bristow Okla
United Drlg Co
8750 Holloway Dr
Los Angeles 46 Calif
Urice Drlg Co
615 Ft Worth Club Bldg
Ft Worth Tex
V S & S Drlg Co
1004 Ridgley Bldg
Springfield Ill
V-T Drlg Co
711 Hulman Bldg
Evansville Ind
Varner-Neill Drlg Co
1674 N Treadaway
Abilene Tex
W H Varner Drlg Co
1674 N Treadaway
Abilene Tex
Veeder Supply & Dev Co
Box 201
Cherryvale Kans
Velma Petroleum Corp
Box 1955
Hobbs N Mex
Viersen & Cochran
Box 280
Okmulgee Okla
Viking Drlg Co
102 W Crockett St
San Antonio 5 Tex
W L B Drlg Co
6635 Chocolate Bayou Rd
Houston Tex
Wade Drlg Co
Box 70
Cushing Okla
Wagner & Wyant Drlg Co Inc
414 Petroleum Bldg
Amarillo Tex
J H Wagner Drlg Co
Box 751
Eldorado Kans
Walters Drlg Co Inc
4114 McMillan
Dallas 6 Tex
Walters Drlg Co Inc
510 Orpheum Bldg
Wichita Kans
Rusty Walters Drlg Co
Box 304
Bakersfield Calif
Walton Drlg Co
Box 241
Fairfield Ill
Ward Drlg Co
106 Oil & Gas Bldg
Wichita Falls Tex
Tommy Ward Drlg Co
1415 Liberty Bk Bldg
Oklahoma City Okla
Warton Drlg Co
Box 2807
Odessa Tex
Carnes W Weaver Drlg Co
326 Gulf Bldg
Houston Tex
C B Webster Drlg Co
609 San Jacinto Bldg
Houston Tex
Webster Drlg Co
424 S Cheyenne
Tulsa Okla
Dick Wegener Drlg Contr
1820 First Natl Bldg
Oklahoma City Okla
Wells Drlg Co
5382 Cherry Ave
Long Beach Calif
Art West Drlg Co
Rm 217 O'Michael Bldg
Odessa Tex
West Central Drlg Co
717 Citizens Bk Bldg
Abilene Tex
Western Drlg Co Inc
902 Lubbock Natl Bk Bldg
Lubbock Tex
Western Serv Drlg Co Inc
Box 1428
Odessa Tex
Wes-Tex Drlg Co
Box 2058
Abilene Tex
Chester H Westfall Drlg Co
1202 Hunt Bldg
Tulsa Okla
Westlund Drlg Co
Box 197
Midland Tex
Chet Whaley Well Serv Co Inc
6006 Milart St
Houston Tex
Wheless Drlg Co
Box 368
Shreveport La
Wilbanks & Rutter Drlg Co
2200 Scurry St
Big Spring Tex
Wilcox Drlg Co
Box 365
Covington Okla

A W Williams Drlg Co Inc
411 Virginia St
Mobile Ala
Kidd Williams Drlg Corp
205 Kennedy Bldg
Tulsa Okla
Walter W Willis
813 Broadway
Mt Vernon Ill
Wilson Drlg Co
Box 933
Jackson Miss
C R Winn Drlg Contr
Box 331
Salem Ill

Wise Drlg Account
Box 297
Tyler Tex

Woodson Prod Co
1333 N 2nd
Abilene Tex

Woolf & Magee
Box 635
Tyler Tex

Yarborough Drlg Co
735 Wilson Bldg
Corpus Christi Tex

S P Yates Drlg Co
309 Carper Bldg
Artesia N M

Marshall R Young Drlg Co
Box 712
Brookhaven Miss

Zapata Off-Shore Co
2218 City Natl Bk Bldg
Houston Tex

Zephyr Drlg Corp
1111 First Natl Bldg
Tulsa Okla

U. S. Contract ROTARY Drilling Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ALABAMA						
Choctaw County						
A W Williams Drlg Co Inc	1	dsl	186	Joy 300	200	5,500/2⅞"
Mobile County						
Zach Brooks Drlg Co	1	dsl	1100	Brwstr N-10	1455	11,000
Dixilyn Drlg Corp	5	gas	950	Natl 100	950	14,000
Gulf Coast Drlg & Explo Inc	3	dsl	900	Natl 80-B	900	12,500
Index Drlg Co	2-B	LPG	250	Beth S-45	250	6,000/3½"
Justiss-Mears Oil Co Inc	7	dsl	700	Emsco J-750	1000	11,500
Washington County						
Zach Brooks Drlg Co	7	dsl	1100	Brwstr N-75	1455	11,000
ARIZONA						
Apache County						
Fleeger Drlg Inc	1	dsl	325	Beth Twstr	600	7,500
ARKANSAS						
Columbia County						
C A Hilburn Drlg Contr	2	gas	550	Wisn	—	10,000
Maritzky & Bibby	2	gas	330	Crdwll	145	3,000
McAlester Fuel Co	—	btne-gas	—	Emsco GC-500	820	11,000
	—	dsl	—	Crdwll Trlrg	275	5,500
Penrod Drlg Co	16	gas-btne	—	—	1500	15,000
	38	gas-btne	—	—	1170	10,000
Lafayette County						
W C Allen Drlg Co	2	gas-btne	145	Wisn Super	78	3,000/3½"
Johnson Drlg & Serv Co	2	dsl	225	Beth Twstr	300	6,500
Logan County						
Viersen & Cochran	10	gas	325	Natl 50	—	8,800
Miller County						
Arrow Drlg Co	16	gas-elec	840	Emsco	—	10,000
Pyburn Drlg Co	2	gas	250	Wilson	800	9,000
Trimble Drlg Co Inc	2	dsl	310	Emsco GB-250	310	6,500
Woolf & Magee Inc	10	gas-btne	275	Beth Breeze	275	8,000/2⅛"
Saline County						
Walters Drlg Co Inc	1	gaso	260	Mayhew 1000	260	1,200/2⅛"
	3	gas	130	Mayhew	130	1,000
	4	gas	130	Mayhew 1000	130	600/2⅛"
	5	gas	150	Mayhew 1000	150	600/2⅛"
	6	gaso	130	Mayhew 1000	130	300/2⅛"
	7	gas	175	Mayhew 1000	175	900/2⅛"
	8	gas	220	Mayhew 1000	220	600/2⅛"
	9	gaso	130	Mayhew 1000	130	800/2⅛"
	11	gas	150	Mayhew 1000	150	600/2⅛"
	15	gas	500	Mayhew 2000	500	2,500/2⅛"
Union County						
Alan Drlg Co	3	gas	275	Wisn Mogul	145	3,500
Mercury Drlg Corp	1	gas	200	Ideco H-20	200	3,500
White County						
Walters Drlg Co Inc	13	gas	200	Mayhew 1000	200	600/2⅛"
CALIFORNIA						
Butte County						
B J & M Drlg Co Ltd	3	gas	450	Natl 50	775	8,500
Colusa County						
Gene Reid Drlg Inc	8	dsl	340	Hopper GTA-6	110 300	6,000/2⅛"
Fresno County						
Lee Gibson Oil Co	1	btne	260	Hopper GD	300	5,000
John S Hagestad Drlg Co	3	dsl	625	Emsco GB-350	400	7,000
Rocky Mountain Drlg Co	10	gas	1200	Emsco J-1000	1550	15,000
San Joaquin Drlg Co Inc	4	gas	1260	Natl 75	750	10,500
Santa Maria Drlg Corp	2	gas	400	Wisn Giant	600	5,000
	5	gas	750	Wisn Atlas	900	10,000
Glenn County						
Green & Heiser Drlg Co	1	dsl	835	"Oilwell" 66	550	9,500
Kern County						
B J & M Drlg Co Ltd	4	dsl	600	Natl 50	600	8,500
Barnes Core Drlg Co	D-6	dsl	225	Custom	225	4,000/3½"
	D-10	dsl	450	Custom	450	5,500/3½"
	D-11	dsl	225	Custom	225	3,000/3½"
Camay Drlg Co	1	gas	1075	Emsco J-1000	1000	12,000
Casner & Bentz	1	gas-btne	445	Emsco GA-250	195	4,500
Coastal Drlg Co	4	gas	1000	Emsco GB-800	1050	12,000
H Davis & R H Thompson Co	1	dsl	300	Emsco G-300	300	6,000
	2	dsl	300	Emsco GA-250-T	300	6,000
Douglas Drlg Co	1	btne	125	Emsco	125	2,500
Enterprise Oil Co	3	dsl	300	Wisn Torcair	150	4,000/3"
	4	dsl-LPG	300	Howard-Turner	220	2,800
Armstrong Fowler Inc	1	dsl	610	Natl 50-CA	450	7,500
	2	dsl	200	Natl T-12	250	2,500
Green & Dreblow Drlg Co	—	dsl	600	Wisn Giant	600	7,500
John S Hagestad Drlg Co	1	dsl	570	Emsco GB-350	400	7,000
	2	dsl	540	Ideco H30-D	340	4,500
	4	dsl	680	Ideco H-525	440	7,500
Clyde Hall Drlg Co Inc	5	gas-btne	1000	Emsco GB-800	1000	12,000
Hayes & Sprague Inc	1	gas	1050	Wisn Titan	1050	13,000
	2	dsl	1950	Natl 125	1950	16,000
Ivy Drlg Co	1	dsl	185	Hopper IG	185	1,500
	2	btne	185	Hopper GF	185	3,000
K L Kellogg & Sons	25	dsl	1480	Natl 75	1480	9,500
	29	gas	1370	Natl 75	700	9,500
	32	gas	1400	Natl 75	1050	9,500
Knight Drlg Co	1	dsl	1020	Unit U-35D	340	5,500
Loffland Bros Co	131	dsl	1000		1000	12,000
Miller & York	A	dsl	825	Emsco GC-500	825	10,000
	F	dsl	735	Emsco GA-500	550	8,000
	G	dsl	275	Emsco G-36	275	5,000
	H	dsl	275	Emsco GA-250	275	5,000
	J-11	dsl	210	Hopper GTA	210	3,500
	1	dsl	275	Franks Clipper	225	3,500
Gene Reid Drlg Inc	2	dsl	680	Ideco 525	600	7,000
	4	dsl	680	Ideco H-40	340	5,000
	10	dsl	340	Wisn Mogul	340	4,000
Rocky Mountain Drlg Co	2	gas	1200	Natl 75	900	11,000
	13	gas	1200	Emsco J-1250	1500	20,000
San Joaquin Drlg Co Inc	1	gas	700	Natl 75	750	9,500
	3	gas	1260	Wisn Titan	1300	15,000
	6	gas	1260	Natl 125	1250	15,000
Santa Fe Drlg Co	13	gas	1050	Wisn Titan	900	10,000
Swett Bros Drlg Co	1	prop	250	Hopper	200	3,500
	2	prop	150	Crdwll	150	2,000
Rusty Walters Drlg Co	1	dsl	300	Cooper D-50	300	6,500/4"
	1	dsl	300	Wisn Mogul	300	7,000/4"
Kings County						
K L Kellogg & Sons	31	gas	1580	Natl 125	1050	16,000
Los Angeles County						
Camay Drlg Co	5	gas	535	Natl 50	500	7,000
	6	gas	605	Natl 50	500	7,000
	7	gas	535	Emsco G-300	300	6,000
Drlg & Prod Co	1	dsl	325	Crdwll	420	6,000
	2	dsl-gas-gaso	325	Crdwll O	432	6,000
F E Gober Drlg Co	2	gas	816	Natl 50-A	—	7,500
International Drlg Co	1	gas	770	Natl 50	450	6,500
Fred Johnson Drlg Co	—	gas-gaso	1400	Wisn Titan	1050	10,000
	—	gas-gaso	800	Emsco G-450	700	6,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
	—	gas-gaso	1050	Wisn Titan	700	10,000
	—	gas-gaso	1050	Emsco J-1000	1050	12,000
Kee & Simpson Drlg Co	1	gas-btne	—	Natl 50	380	6,500
	2	gas-btne	—	Beth 58	420	7,000
K L Kellogg & Sons	18	gas	925	Natl 50	650	7,000
	19	dsl	1200	Natl 75	790	9,500
	27	gas	2000	Natl 100	1050	13,000
	28	dsl	1350	Natl 100	1100	13,000
	35	dsl	1800	Natl 130	1800	18,000
Loffland Bros Co	132	gas	870	—	900	10,000
	134	gas	800	—	900	10,000
	141	gas	1000	—	1500	18,000
Macrate Prod Co	2	dsl	175	Ideco HD-30	190	3,500
	7	gas	300	Wgnr Mrhse	250	4,000
Rocky Mountain Drlg Co	6	gas	1200	Emsco J-1000	1550	15,000
Santa Maria Drlg Corp	1	gas	850	Wisn Titan	1200	10,000
Southern Drlg Co	1	gas	225	Crdwll H	145	2,500
The Sun Drlg Co	1	dsl	950	Natl 110	1425	12,000
	2	gas	1400	Natl 125	1250	15,000
Terminal Drlg & Prod Co	3	dsl	—	Wisn Mogul	350	5,000
	4	gas	—	Ideco H-40	460	6,000
	5	dsl	—	Ideco H-40	350	5,000
Wells Drlg Co	1	dsl	650	Unit U-10	350	5,000
	2	dsl	325	Wldrp Blitz 622	350	4 500
Madera County						
Gene Reid Drlg Inc	6	dsl	340	Unit U-10	340	5,000
Monterey County						
Coastal Drlg Co	2	dsl	800	Emsco J-750	1320	11,000
Orange County						
K L Kellogg & Sons	23	gas	2090	Natl 75	790	9,500
Rocket Drlg Co	1	gas-btne-prop	555	Emsco G-300	350	4,500
Santa Fe Drlg Co	3	gas	900	Emsco G-500	440	7,500
	23	dsl	300	Ideco H-40	300	6,000
	25	gas	1050	Natl 55	900	10,000
Terminal Drlg & Prod Co	1	gas	—	Natl 50	440	7,000
Sacramento County						
B J & M Drlg Co Ltd	1	dsl	600	Unit 35-D	400	7,000
Green & Heiser Drlg Co	2	dsl	715	"Oilwell" 66	550	9,500
San Benito County						
Miller & York	C	dsl	550	Emsco GB-350	425	6,500
Petrolex Inc	1	dsl	280	Hopper Blitz	150	5,000/3½"
San Bernardino County						
Santa Rosa Drlg Co	1	prop-gas	155	—	130	2,000
San Mateo County						
B J & M Drlg Co Ltd	2	gas	450	Emsco GA-500	450	7,500
Santa Barbara County						
Casner & Bentz	2	gas-btne	800	Emsco GA-450	550	8,000
Gene Reid Drlg Inc	1-A	dsl	680	Natl 55	680	9,000
Santa Maria Drlg Corp	3	gas	850	Wisn Titan	1200	10,000
	4	gas	500	Wisn Giant	900	7,500
The Sun Drlg Co	4	elec	750	Natl 110	1100	15,000
Solano County						
Santa Fe Drlg Co	11	dsl	300	Wgnr-Mrhse	300	6,000
Ventura County						
Camay Drlg Co	2	gas	1080	Wisn Titan	1000	12,000
	3	gas	855	Natl 75	650	9,000
	4	gas	555	Emsco 500	500	7,500
	9	gas	1900	Natl 130	1900	16,000
International Drlg Co	5	gas	1050	Wisn Titan	1050	12,000
	6	dsl	1040	Wisn Spr Titan	780	12,000
K L Kellogg & Sons	7	gas	2240	Natl 100	1050	13,000
	33	gas	1750	Emsco GB-800	1050	12,000
	34	gas	2475	Natl 125	2475	16,000
	36	gas	2475	Natl 125	2475	16,000
Loffland Bros Co	2	gas	1350	—	1350	20,000
	6	gas	1500	—	1400	16,000
	9	gas	1500	—	1400	16,000
	19	gas	1000	—	900	10,000
	111	gas	1000	—	1040	11,000
Rocky Mountain Drlg Co	1	gas	1200	Natl 75	900	11,000
	3	gas	1200	Natl 100	900	14,000
	4	gas	1400	"Oilwell" 96	1750	20,000
	5	gas-dsl	1480	"Oilwell" 96	1850	20,000
	7	gas	1200	Natl 100	1110	15,000
	8	gas	1400	Natl 125	1750	20,000
	9	gas	1200	Natl 125	1500	20,000
	12	gas	1480	Natl 125	1850	20,000
	14	gas	1200	Emsco J-1250	1500	20,000
	15	gas	1200	Emsco J-750	900	11,000
San Joaquin Drlg Co Inc	2	gas	1530	Natl 110	1100	15,000
	5	gas	1260	Natl 125	1250	15,000
Santa Fe Drlg Co	9	gas	1050	Wisn Titan	900	10,000
	26	gas	1050	Wisn Titan	900	10,000
Severns Drlg Co	1	gas	650	Natl 100	1325	13,000
Terminal Drlg & Prod Co	2	dsl	—	Natl 50-A	700	8,500
	6	dsl	—	Emsco GC-500	440	7,000
	17	dsl	—	Wisn Mogul	350	5,000
	18	dsl	—	Ideco H-525	540	8,000
United Drlg Co	1	gas	380	Emsco EDA	450	6,000
Yolo County						
Coastal Drlg Co	1	dsl	1500	Emsco J-1250	1920	16,000
COLORADO						
Adams County						
B F Allison Drlg Co	4	gas-btne	900	Brwstr N-75	900	11,000
Herndon Drlg Co	8	gas	600	Natl 50-A	750	10,500
Arapahoe County						
Don M Rounds Drlg Co Inc	2	dsl	900	Crdwll O	900	9,000
Baca County						
Herndon Drlg Co	3	gas	600	Natl 90	750	8,000
Garfield County						
Camay Drlg Co Rocky Mt Div	6	dsl	260	Johnson	450	5,000
Jefferson County						
Taylor Expl Co Inc	2	gaso	—	Failing	—	1,500
	3	gaso	—	Mayhew	75	1,000
	7	btne	—	Mayhew	—	1,200
Kiowa County						
Wagner & Wyant Drlg Co Inc	1	dsl	300	Unit U-15	450	8,000
La Plata County						
Fleeger Drlg Inc	6	gas	450	Unit U-15	600	8,000
Kent Drlg Co	—	dsl	—	Natl 75 CE	1050	10,500
Loffland Bros Co	13	dsl	1000	—	1200	14,000
Larimer County						
Miracle-Fifer Drlg Co	1	btne	300	Unit U-15	660	8,500
Logan County						
Herndon Drlg Co	4	gas	480	Emsco G-450	630	7,000
Miracle-Fifer Drlg Co	2	btne	300	Unit U-15	660	8,500
Moffat County						
B F Allison Drlg Co	2	gas-btne	675	Unit U-15	675	8,500
Carmack Drlg Co	1	dsl	680	Natl 50-A	450	8,000
	5	gas	400	Natl T-32	320	6,000
	7	dsl	300	Natl T-12	300	4,000
Rowan Drlg Co Inc	24	gas-btne	504	Natl 50	1077	8,500
Montezuma County						
Rocket Drlg Co Inc	2	dsl	—	—	520	7,500
Morgan County						
B F Allison Drlg Co	1	gas-btne	450	Crdwll S	225	5,500
	5	gas-btne	450	Franks 137	390	5,500
Falcon Seaboard Drlg Co	MA-1	gas-btne	300	Unit U-35	—	6,500
Garvey Drlg Co	16	dsl	300	Wisn Roadair	450	7,000/3½"
Otero County						
Wagner & Wyant Drlg Co Inc	2	dsl	300	Unit U-15	675	8,000
Prowers County						
Branyan Drlg Co	2	dsl	700	Beth	700	9,000
Rio Blanco County						
Camay Drlg Co Rocky Mt Div	2	gas	600	Emsco-GA-500	500	7,500
Washington County						
Exeter Drlg Co	2	btne	320	Emsco GA-250	250	6,000/4"
Garvey Drlg Co	12	dsl	300	Wisn Giant	320	6,000/3½"
Weld County						
Baird & Pfeifer Drlg Co	2	gas	300	Unit U-15	—	7,500
Dyer Drlg Co	2	gas-gaso	325	"Oilwell" 64-B	480	7,000
Exeter Drlg Co	1	dsl	325	Emsco GA-350	425	7,000
Exploration Drlg Co	1	gas	310	Beth S-60	250	6,000
Loffland Bros Co	8	gas	1000	—	1200	16,000
	94	dsl	970	—	1275	11,000
Yuma County						
Edgar Davis Drlg Co	11	gas-btne	325	Unit U-15	600	7,500
FLORIDA						
Lee County						
Dorris Ballew Inc	3	dsl	760	Wisn Titan	1900	15,000
St. Lucie County						
Dorris Ballew Inc	2	dsl	760	Wisn Titan	1300	12,500
ILLINOIS						
Bond County						
Troop Drlg Co	1	gas-gaso	—	Natl T-20	200	4,500
C R Winn Drlg Contr	2	dsl	225	Crdwll L	225	4,000/3½"
Clark County						
Donald P Knierim	3	gas	180	Failing 2500	—	2,500/3½"
Clay County						
Central Drlg Co (Fairfield Ill)	4	dsl	—	—	—	4,000
Herndon Drlg Co	5	gas	375	Brwstr N-4	375	4,500
Ted Lindsay	2	dsl	220	Natl T-16	220	5,000
The Noah Petroleum Co	1	dsl	300	Brwstr N-4	300	5,500
J W Rudy	1	dsl	150	Natl T-20	185	5,000

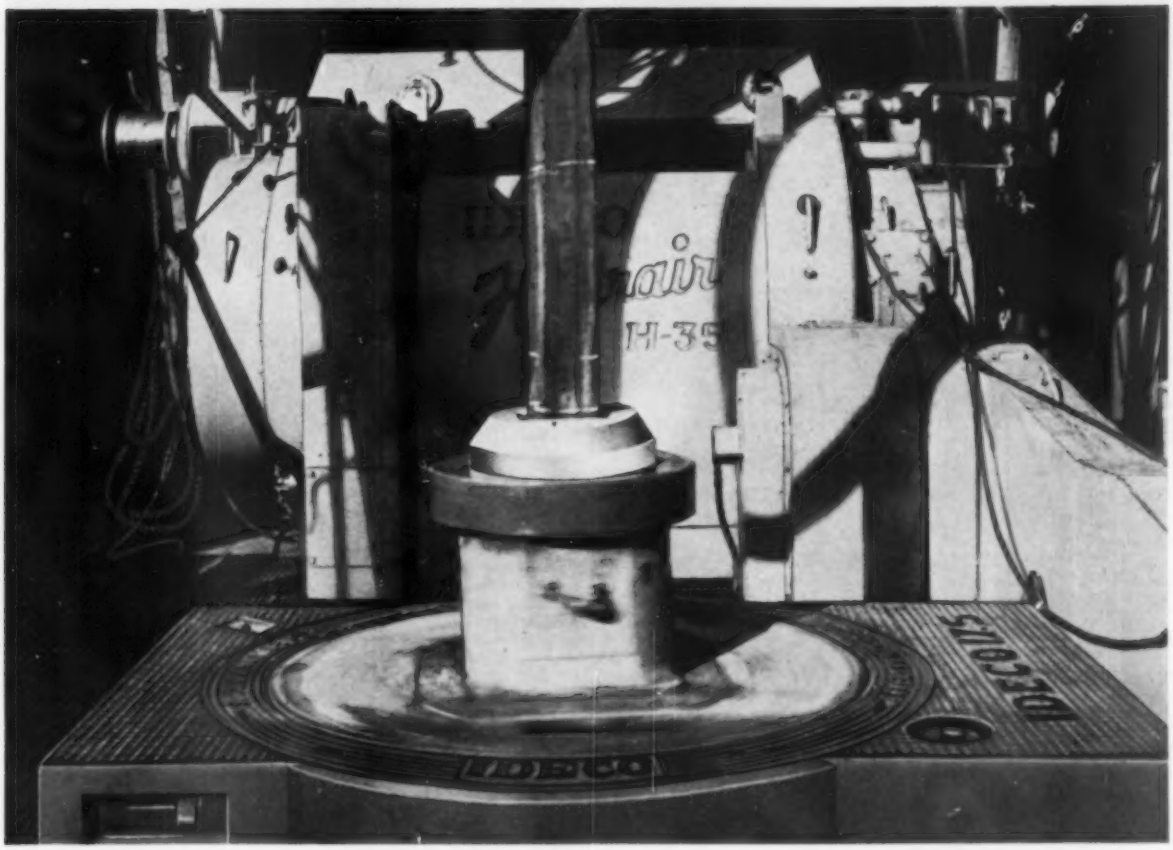
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Shulman Bros	1	dsl	330	Crdwll S-350	—	5,500
	2	dsl	330	Crdwll L	—	3,500
Clinton County						
Conrey Drlg Co	1	gas	140	Wisn Super	140	2,000/3½"
M Mazzarino	—	gas-gaso	200	Frnks 2000	200	2,500
Perrine & Perrine Drlg Contr	1	btne	—	Crdwll S	185	6,000
Coles County						
U & E Drlg Co	—	dsl	400	Crdwll S	200	3,500
Crawford County						
W L Dillier	2	gas	—	Failing 2500	130	2,000
Effingham County						
Calvert Drlg Inc	8	dsl	260	Ideco H-30	190	4,500
Graham Powell	1	dsl	—	Natl 50	—	6,000
Fayette County						
Calvert Drlg Inc	16	dsl	260	Ideco H-35	190	5,000
Claypool Drlg Co	R-2	btne	185	Natl N-40	185	4,500
V S & S Drlg Co	2	dsl	—	Wisn	—	2,400
Gallatin County						
Calvert Drlg Inc	12	dsl	260	Ideco H-30	260	4,500
V S & S Drlg Co	4	dsl	—	Beth	—	4,200
Hamilton County						
C E Brehn	2	dsl	250	Brwstr N-45	—	7,000
Pep Drlg Co	1	dsl	330	Beth Breeze	340	5,000
Jefferson County						
Petro Drlg Co Inc	1	dsl	450	Brwstr N-4	300	6,500
Don Slape Drlg Co	3	dsl	260	"Oilwell" 64-B	230	5,500
Kankakee County						
D B Lesh Drlg Co	1	dsl	200	—	—	4,000
	2	dsl	320	—	—	5,500
Lawrence County						
Henson Drlg Co	6	dsl	250	Unit U-24	150	2,000
Walton Drlg Co	1	gas	—	Failing 2500	—	2,000/3½"
	2	gas	—	Failing 2500	—	2,000/3½"
Marion County						
Conrey Drlg Co	2	dsl	175	Wisn Super	175	2,500/3½"
C R Winn Drlg Contr	1	dsl	135	Wisn Super	135	3,000/4½"
Montgomery County						
Ted Lindsay	1	dsl	160	Ideco H-30	160	4,000
Richland County						
J W Rudy	50	dsl	250	Natl 50	214	6,000
Don Slape Drlg Co	1	dsl	260	"Oilwell" 64-A	230	5,000
	2	dsl	240	Unit U-34	230	4,500
Saline County						
C E Brehn	1	dsl	240	Brwstr N-45	—	7,000
Eakle & Holder Drlg Co	2	dsl	200	Emsco G-300	—	5,500
D B Lesh Drlg Co	4	gas	450	—	—	7,000
Lohmann-Johnson Drlg Co Inc	7	gas	300	Crdwll S	440	4,500
B L Rucker Drlg Co	1	dsl	318	Beth 45-E	—	5,000
Walter W Willis	1	dsl	278	Beth 430-S	—	4,500
Wabash County						
Harris Drlg Co	2	btne	276	Natl 40	172	4,000
Houchins Drlg Co	1	gas	185	Natl T-12	185	4,500
Olds Oil & Chem Corp	1	btne	—	—	200	3,500
Paco Petroleum Corp	3	dsl	320	Unit U-35	320	7,000
Washington County						
Graham Powell	2	dsl	—	Natl T-12	—	3,200
Wayne County						
Calvert Drlg Inc	11	dsl	260	Natl T-32	190	5,000
Central Drlg Co (Fairfield Ill)	6	btne	260	—	—	4,000
D B Lesh Drlg Co	3	dsl	200	—	—	4,000
White County						
Big Seven Drlg Co	1	dsl	300	Emsco GB	300	4,500
Claypool Drlg Co	R-1	btne	225	Natl T-20	185	4,500
Eakle & Holder Drlg Co	3	dsl	300	Ideco H-30	—	5,500
Eastern Drlg Inc	1	dsl	266	Natl T-20	—	5,000
Forbanta Drlg Co	1	gas	250	Crdwll S-140	200	4,500
Harris Drlg Co	3	dsl	285	Natl 50	285	8,500
Herndon Drlg Co	7	gas	409	Natl T-32	559	4,500
	9	gas	240	Natl T-25	390	4,000
Kendall-Davis Drlg Co Inc	1	dsl	300	Wisn Mogul	300	4,000
Lauderdale Drlg Inc	1	dsl	300	Brwstr N-4	300	4,500
Ted Lindsay	3	dsl	220	Crdwll S	160	4,500
Paco Petroleum Corp	1	dsl	320	Natl T-32	320	6,000
Pep Drlg Co	2	dsl	330	Ideco H-35	340	6,000
Walter W Willis	2	dsl	256	Natl T-12	—	4,500
Williamson County						
Calvert Drlg Inc	15	dsl	260	Ideco H-35	260	5,000
INDIANA						
Gibson County						
Central Drlg Co	1	gas	225	Natl 40	185	4,500
	1	dsl	225	Unit U-34	225	4,000
W L Dillier	1	gas	—	Natl T-12	212	3,000
	3	gas	—	Failing 2500	130	2,000
Harris Drlg Co	1	btne	195	Crdwll S	172	4,000
Highland Oil	2	—	—	B Erie 28-L	—	2,000
Marion County						
Tri-County Expl Co Inc	1	gaso	25	Reich Bros	100	1,200/2½"
Pike County						
Henry Gwaltney Drlg Co	1	dsl	200	Natl T-12	165	3,000
Olds Oil & Chem Corp	2	btne	—	—	85	1,500
Posey County						
Advance Drlg Co	3	dsl	380	Beth Breeze	370	5,000/3½"
Lohmann-Johnson Drlg Co Inc	6	gas	300	Crdwll S	400	4,500
Gene Miller Inc	5	dsl	300	Brwstr N-4	—	4,500
Paco Petroleum Corp	2	btne	200	Wisn Mogul	165	4,000
Sullivan County						
U & E Drlg Co	—	dsl	500	Frnks 4500	400	5,000
Vanderburgh County						
Stouder Drlg Co	2	LPG	200	Natl T-12	160	4,000
IOWA						
Dallas County						
Kirby Oil Ind	—	gas-gaso	—	Mayhew 3000	145	3,000
	—	dsl	—	Unit U-34	275	4,500
KANSAS						
Barber County						
Harry Bass Drlg Co	114	gas	570	Crdwll	570	7,000
Bennett & Roberts Drlg Co	3	dsl	250	Emsco 250	250	5,000
D & M Drlg Co Inc	2	gas-btne	225	Brwstr N-4	280	5,000
Herndon Drlg Co	1	gas	409	"Oilwell" 64-B	559	6,000
Iron Drlg Co	6	dsl	240	Emsco GA-250	268	5,000
Patton Drlg Co Inc	1	gas	—	Natl 50	450	6,500
Prime Drlg Co	5	dsl	300	Natl T-20	300	5,000
Barton County						
Harms-Burt Drlg Co	2	dsl	160	Emsco 350	350	6,500
Iron Drlg Co	7	dsl	268	Emsco GB-160	236	4,500
Clark County						
Helmerich & Payne Inc	7	gas	500	Emsco GB-500-82	700	9,000
Unit Drlg Co	3	dsl	700	Natl 50-A	700	6,500
Clay County						
Rocket Drlg Co Inc (Kans)	1	dsl	—	—	520	7,500
Cowley County						
Capitt Drlg Inc	2	dsl	300	Beth S-45	285	5,000
Criswell Drlg Co	1	dsl	300	Unit U-34	275	4,500
Edwards County						
Herndon Drlg Co	10	gas	409	"Oilwell" 64-A	559	4,500
Ellis County						
Graham-Michaelis Drlg Co	6	dsl	275	Beth Breeze	175	4,000
Isern Drlg Co	1	dsl	450	Unit U-15	450	7,000
Mallonee Drlg Co Inc	1	btne	220	Beth Breeze	200	4,500
Musgrove Petroleum Corp	8	dsl	230	Natl 50	—	5,000
Powell Drlg Co	1	dsl	—	Emsco GB-350	350	6,500
Prime Drlg Co	2	dsl	300	Beth S-45	300	5,000
	3	dsl	275	Unit U-34	285	4,500
Stickle Drlg Co	4	dsl	300	Ideco H-35	300	5,000
Veeder Supply & Dev Co	D	dsl	280	Natl T-25	300	4,500
Walters Drlg Co	1	gas	—	Natl 50	500	5,500
Finney County						
Garvey Drlg Co	5	dsl	175	Unit U-15	296	5,000
Graham-Michaelis Drlg Co	3	dsl	300	Crdwll S	175	5,000
Graham County						
Garvey Drlg Co	14	dsl	175	Wisn Giant	296	5,000
Harms-Burt Drlg Co	1	dsl	150	Emsco 250	250	5,000
Greenwood County						
Greenwood Pet Mgmt Inc	1	dsl	—	Frnks 5000	—	—
Harper County						
Garvey Drlg Co	10	dsl	175	Wisn Giant	296	5,000
Graham-Michaelis Drlg Co	8	dsl	400	Crdwll D	400	5,000
Lewis Drlg Co	4	dsl	450	Crdwll	450	6,000
Rupp-Ferguson Oil Co	1	dsl	350	Ideco H-35	350	5,000
Stickle Drlg Co	6	dsl	300	Brwstr N-45	300	6,500
Hodgeman County						
Graham-Michaelis Drlg Co	1	dsl	275	Beth Twister	500	6,500
Kingman County						
Beardmore Drlg Co	1	dsl	300	Natl 50	450	6,000
Gabbert-Jones Drlg Co	1	gas	320	Emsco 300	300	5,000
Garvey Drlg Co	9	dsl	175	Wisn Giant	296	5,000
Stickle Drlg Co	5	dsl	300	Natl T-32	300	5,500
Kiowa County						
Falcon Seaboard Drlg Co	20	gas-btne	320	Unit U-15	—	8,500
	26	dsl	225	Beth Twister	—	6,500
Garvey Drlg Co	3	dsl	175	Unit U-15	296	5,000
Graham-Michaelis Drlg Co	4	dsl	500	Unit U-15	500	7,000
Patton Drlg Co Inc	2	dsl	—	Natl 50	350	5,500
McPherson County						
Greenland Drlg Co	1	dsl	190	Emsco 160	190	4,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Mallard Drlg Co	1	dsl	285	Emsco G-300	285	4,000
Veeder Supply & Dev Co	E	dsl	270	Frnks 658	270	3,500
Meade County						
Capitt Drlg Inc	3	dsl	325	Beth C-50	500	10,000
D & M Drlg Co Inc	3	dsl	600	Unit U-15	600	7,500
Gabbert-Jones Drlg Co	2	gas	450	Emsco 350	450	7,000
Garvey Drlg Co	21	dsl	500	Unit U-15	640	8,500
Lewis Drlg Co	2	dsl	550	Unit U-15	550	6,000
Midwestern Drillers Inc	2	dsl	320	Unit U-15	600	7,500
Nye & Snell Drlg Co	1	gas	375	"Oilwell" 66	550	6,000
Stickle Drlg Co	2	dsl	550	Natl T-32	300	6,000
Morton County						
Garvey Drlg Co	15	dsl	175	Wisn Giant	296	5,000
Holm Drlg Co	4	dsl	560	Wisn Giant	300	5,500
	5	dsl	300	"Oilwell" 52-T	300	5,500
Lewis Drlg Co	3	dsl	260	Crdwll	260	±5,500
Ness County						
Bennett & Roberts Drlg Co	2	dsl	250	Emsco 250	250	6,000/3½"
Norton County						
Lohmann-Johnson Drlg Co Inc	3	gas	300	Natl 50	450	5,500
Pawnee County						
Gabbert-Jones Drlg Co	3	gas	320	Emsco 300	300	5,000
Rice County						
Beardmore Drlg Co	2	dsl	300	Emsco 300	320	4,000
Bennett & Roberts Drlg Co	1	dsl	250	Emsco 250	250	5,000
Buick Drlg Inc	2	dsl	300	Wilson	—	4,500
Donald T Ingling	2	btne	—	Brwstr CR-300	270	4,000
Rooks County						
Anschutz Drlg Co Inc	1	dsl	330	Wisn Giant	280	5,000
Reserve Drlg Co Inc (Kans)	3	dsl	220	Natl T-32	—	5,500
Transit Corp	2	dsl	230	Emsco	—	4,500
Rush County						
Lewis Drlg Co	1	dsl	250	Crdwll	225	4,500
Shelley-Miller Drlg Co	1	dsl	—	Wisn	—	5,500
Transit Corp	4	dsl	250	Emsco	—	4,500
Russell County						
Shields Drlg Co Inc	2	dsl	300	Beth C-50	300	8,000
Sedgewick County						
Ainsworth Inc	2	gaso	100	Failing	100	1,500/2⅛"
Seward County						
D & M Drlg Co Inc	1	gas-btne	550	Natl 50	550	7,500
Musgrove Petroleum Corp	3	dsl	440	Natl 50	—	5,500
R W Rine Drlg Co	3	gas-btne	520	Unit U-15	600	7,500
Sheridan County						
Empire Drlg Co (Kans)	2	dsl	300	Natl T-32	300	5,000
Stafford County						
Garvey Drlg Co	11	dsl	175	Wisn Giant	296	5,000
Transit Corp	3	dsl	230	Emsco	—	4,500
Stanton County						
Graham-Michaelis Drlg Co	2	dsl	500	Unit U-15	500	7,000
R W Rine Drlg Co	1	gas-btne	620	Unit U-15	600	7,500
Stevens County						
Moran Bros Inc	14	dsl	275	Natl T-12	300	4,500
Sumner County						
Herndon Drlg Co	6	gas	409	Natl T-32	559	6,000
KENTUCKY						
Daviess County						
Hupp & Hume	2	dsl	117	Natl 40	300	3,000
Henderson County						
Basin Drlg Co Inc	2	dsl	220	"Oilwell" 64	300	6,500
Hopkins County						
Basin Drlg Co Inc	1	dsl	220	"Oilwell" 64-B	300	6,500
Kendall-Davis Drlg Co Inc	2	dsl	300	Crdwll S	300	4,000
Stouder Drlg Co	1	LPG	200	Natl 40	160	4,500
Lee County						
Henry Gwaltney Drlg Co	2	gas-prop	200	Crdwll	165	3,000
Overby Drlg Co	2	dsl-btne	250	Mayhew 2000	—	2,500
McLean County						
General Geophysical Co	27	dsl	—	—	400	4,500
Hupp & Hume	1	dsl	255	Natl 40	300	4,500
Webster County						
V-T Drlg Co	1	dsl	220	Crdwll H	160	4,000
LOUISIANA						
Acadia Parish						
Bullard Drlg Co Inc	1	stm	1000+	Natl 34-10 FE	1000+	16,000
Falcon Seaboard Drlg Co	2	stm	1200+	Ideco Gnt	—	25,000
	30	stm	1200+	Natl 3410	—	25,000
Gilger Drlg Co	3	stm	800+	Emsco	1000+	11,000
	4	stm	1000	Emsco	1000+	14,000
Win Hawkins Drlg Co	4	stm	—	Natl 3410 FE	—	15,000
Nicklos Drlg Co	10	stm	—	Natl	—	17,000
Sunnyland Const Co Inc	8	gas-gas	—	Crdwll D	312	8,000
Allen Parish						
Penrod Drlg Co	7	dsl	—	—	730	9,000
	23	dsl	—	—	730	9,000
Ascension Parish						
Dorris Ballew Inc	1	dsl	760	Wisn Titan	1300	12,500
Brewster-Bartle Drlg Co Inc	10	gas	—	"Oilwell" 76	700	11,000
Assumption Parish						
Bullard Drlg Co Inc	3	stm	1000+	Ideco Big Gnt	1000+	16,000
Delta Drlg Co	19	stm	1200	Natl 34-10 FE	1690	15,000
Gracey-Hellums Corp	2	stm	1200	Natl 23-9 FE	1200	15,000
Grey Wolf Drlg Co	1	gas-btne	945	Emsco GB-800	—	12,500
W P Taylor Drlg Co	1	gas	—	Emsco	1000	13,000
Wheless Drlg Co	7	stm	1000+	Emsco UBLS	1000+	15,000
Avoyelles Parish						
Nicklos Drlg Co	14	gas-btne	—	Natl 75	1000	12,000
Beauregard Parish						
Crown Rigs Inc	6	gas	900	Beth MC-450	600	10,000
Bienville Parish						
Penrod Drlg Co	9	dsl	—	—	385	6,000
	40	gas-btne	—	—	580	7,000
Trimble Drlg Co Inc	1	dsl-btne	240	Brwstr N-4	310	5,000
Bossier Parish						
B-M Drlg Co Inc	1	gas	440	Frnks SAL 600D	440	7,000
Ruhl Drlg Co Inc	1	—	475	Brwstr N-7	625	8,500
Caddo Parish						
W C Allen Drlg Co	1	gas-btne	145	Wisn Super	78	3,000/3½"
Big Chief Drlg Co	31	gas	1155	Emsco 800	1515	13,500
Burnham & Robinson Drlg Co	1	dsl	350	Brwstr N-5	350	7,000
W C Curry Drlg Co Inc	4	gas	145	Ideco 35	145	4,000/2⅛"
	5	gas	145	Wisn Super	145	3,000/2⅛"
Gary Drlg Co	1	btne	90	—	90	2,000
	2	btne	145	—	200	4,000
Greyhound Drlg Co Inc	1	dsl	300	Brwstr N-4	280	5,500
McGoldrick & Watson Drlg Co	1	btne	145	Brwstr N-3	140	3,500
Penrod Drlg Co	21	dsl	—	—	385	6,000
C M Roberson Drlg Co	1	gas-btne	400	Brwstr N-45	400	7,300
Tex-Mex Drlg Co	11	stm	—	—	1000+	12,000
Wheless Drlg Co	2	gas-btne	600	Wisn Atlas	700	8,500
Calcasieu Parish						
A W Eggleston Inc	11	gas-btne	500	Ideco M-10000	627	9,800
Norton Drlg Co	Bge 5	dsl	1200	"Oilwell" 96	1200	17,000
Penrod Drlg Co	26	gas	—	—	730	9,000
C B Webster Drlg Co	4	stm	1200	Natl FE-34-10	1200+	15,000
Cameron Parish						
Harry L Edwards Drlg Co	6	stm	1000+	"Oilwell" 9-P	1000+	15,000
	Bge 10	dsl	—	Ideco PR-1050	—	16,000
Win Hawkins Drlg Co	1	stm	—	Alco BIW 14	—	15,000
	3	stm	—	Emsco UBLS-54	—	14,000
Lofland Bros Co	41	stm	—	—	—	15,000
	59	stm	—	—	—	15,000
Mac Drlg Co	10	gas-btne	1000	Wisn Titan	1300	15,000
	12	stm	500	Natl 23-9-FED	1000+	15,000
Penrod Drlg Co	45	dsl	—	—	1500	20,000
Carnes W Weaver Drlg Co	3	gas-btne	700	"Oilwell"	—	10,500
C B Webster Drlg Co	3	gas	900	Emsco J-1250	1300	15,000
Wheless Drlg Co	Bge 12	gas-btne	1200	Natl 80	800	12,000
Catahoula Parish						
Dorris Ballew Inc	6	dsl	380	Unit U-15	600	7,500
Claiborne Parish						
Arrow Drlg Co	5	gas	1250	Emsco	—	14,000
Delta Drlg Co	8	stm	750	Ideco Supr-Duty	1200	12,000
Jet Drlg Co Inc	3	dsl	1000	Brwstr N-75	700	11,000
	5	gas-btne	700	Emsco 800	800	10,500
Maritzky & Bibby	1	gas	—	Brwstr	185	5,000
McCalman Drlg Co Inc	1	dsl	—	Brwstr N-4	300	5,500
Nichols Drlg Co	5	gas-btne	1350	Natl 75-CA	1350	11,000
Penrod Drlg Co	11	gas	—	—	1425	12,000
Wheless Drlg Co	1	gas-btne	600	Emsco G-42	600	7,500
	5	stm	900	Emsco UBLS-54	1000+	11,000
	Bge 10	gas-btne	900	Brwstr N-7	700	9,500
	13	gas-btne	700	Emsco J-750	750	10,500
Woolf & Magee Inc	5	gas-btne	800	Beth MC-450	—	11,000
Concordia Parish						
Petersen Drlg Co	1	gas	500	Crdwll O	735	10,000
	5	gas	320	Crdwll S	350	6,000
De Soto Parish						
Glenn Drlg Co	2	dsl	280	Unit U-15	450	8,500
East Baton Rouge Parish						
Nicklos Drlg Co	16	stm	—	Emsco	—	16,000
Evangeline Parish						
Penrod Drlg Co	4	gas-btne	—	—	1425	15,000
	22	dsl	—	—	600	9,000
	27	dsl	—	—	1095	11,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Franklin Parish						
Woolf & Magee Inc	12	gas-btne	275	Beth S-45	275	8,000/2⅞"
Iberia Parish						
Clegg & Hunt	4	stm	—	Ideco Bg Gnt	—	15,000
Continental Drlg Co	7	dsl	1200	Emsco GB-800	1200	14,000
Crawford Drlg Co	1	dsl	695	Brwstr N-7	500	9,000
Harry L Edwards Drlg Co	4	stm	1000+	Alco BIW 12	1000+	15,000
Loffland Bros Co	47	stm	—	—	—	15,000
Ruhl Drlg Co Inc	2	stm	—	Natl Ideal	—	13,500
C B Webster Drlg Co	6	stm	1100	Emsco ECA-10½	1200+	15,000
Wheless Drlg Co	Bge 6	gas-btne	1000	Wisn Titan	1000	12,000
Iberville Parish						
Bateman Drlg Co	Bge 6	dsl-elec	900	Emsco UBLS 54-10	1600	16,000
Frank Frawley Drlg Co	1	stm	—	Ideco Bg Gnt	1200	13,000
M M Lindsey Drlg Co	1	gas	380	Hou 876	—	7,500
Southern Six Drlg Co Inc	1	stm	1000+	—	1000+	14,000
	2	stm	1000+	—	1000+	14,000
Sunnyland Contr Co Inc	3	stm	—	Emsco ECB	724	16,000
Jefferson Parish						
Continental Drlg Co	6	dsl	650	Emsco GB-500	650	11,000
Delta Drlg Co	16	dsl	1200	Beth MC-950	1400	15,000
	35	gas-btne	1200	Emsco J-1100	1200	15,000
	37	dsl	900	Beth MC-950	1400	15,000
Doc Drlg Corp	Bge DOC	dsl	1500	Beth Tornado	1500	15,000
Blackie Drlg Co Inc., Neva-Andre Drlg Corp.						
Loffland Bros Co	45	stm	—	—	—	15,000
	63	stm	—	—	—	18,000
Penrod Drlg Co	34	dsl	—	—	1095	12,000
Jefferson Davis Parish						
Brewster-Bartle Drlg Co Inc	14	gas	—	Natl 125	—	16,000
Clegg & Hunt	1	stm	—	Emsco 10	—	15,000
Delta Drlg Co	32	stm	1200	Ideco Big Gnt	1690	15,000
Harry L Edwards Drlg Co	5	stm	1000+	Natl 23-10½FE	1000+	16,000
	7	stm	1000+	Alco BIW 12	1000+	15,000
Gilger Drlg Co	5	stm	1000	Emsco	1000+	14,000
Grey Wolf Drlg Co	2	dsl-elec	1250	Alco BIW 12	1250	15,000
Win Hawkins Drlg Co	2	gas-btne	300	Unit U-15	485	9,000
C B Webster Drlg Co	7	stm	1600	Emsco ECA-10½	1200+	15,000
Wheless Drlg Co	4	stm	1000+	Emsco UBLS-54	1000+	12,000
Lafayette Parish						
Delta Drlg Co	14	stm	900	Ideco Big Gnt	1690	15,000
Falcon Seaboard Drlg Co	11	stm	1000+	Alco BIW 12	—	17,000
	12	stm	1200	Alco BIW 12	—	25,000
R P Phillips Well Serv	Bge 7	gas	400	Wisn Giant	450	7,000
Lafourche Parish						
B B M Drlg Co	7	stm	—	Emsco EC-54	—	18,000
Brewster-Bartle Drlg Co Inc	6	dsl	—	"Oilwell" 96	1500	—
Cron & Gracey Corp	3	dsl	—	TIW CT-5	520	8,000
Delta Drlg Co	5	gas-btne	900	Natl 100	800	12,000
Doc Drlg Corp	Bge DAN	dsl	1500	Beth 1013	1500	18,000
Blackie Drlg Co Inc Bge NEVA		dsl	1500	Beth 1013	1500	18,000
Neva-Andre Drlg Corp						
C G Glasscock Drlg Co	2	dsl	1200	Natl 80-B	—	12,000
Loffland Bros Co	83	stm	—	—	—	15,000
	143	dsl	1220	—	1200	15,000
Mac Drlg Co	3	stm	600	Natl 23-9-S	1000+	15,000
Norton Drlg Co	Bge 6	dsl	1400	Emsco J-1250	1200	17,000
Penrod Drlg Co	44	dsl-elec	—	—	1400	18,000
R P Phillips Well Serv	Bge 2	gas	675	Beth 650	536	10,000
	Bge 3	dsl	175	Wisn Giant	275	Workover
Rowan Drlg Co Inc	Bge 1	dsl-elec	1600	Emsco ECA	2475	18,000
	Bge 3	dsl-elec	2150	Emsco EDA	3455	20,000
	Bge 20	dsl	1120	Natl 75	1300	12,000
Wheless Drlg Co	Bge 9	dsl	1300	Natl 130	1300	16,000
	Bge 11	gas-btne	1200	Emsco J-1250	1250	13,500
LaSalle Parish						
Justiss-Mears Oil Co Inc	6	dsl	250	Emsco G-250	325	7,000/4"
	10	dsl	250	Emsco G-250	325	10,000/2⅞"
Lincoln Parish						
Johnson Drlg & Serv Co	1	dsl	200	Beth-Breeze	200	4,500
Woolf & Magee Inc	1	stm	1000+	Natl 34	1200+	15,000
Ouachita Parish						
Zach Brooks Drlg Co	4	dsl	1100	Brwstr N-75	1455	11,000
Southern Six Drlg Co Inc	6	—	—	—	—	15,000
Plaquemines Parish						
Brewster-Bartle Drlg Co Inc	1	dsl	—	"Oilwell" 96	1500	16,000
	12	dsl	—	"Oilwell" 96	1500	16,000
Continental Shelf Drlg Corp	Belle Claire	dsl	1700	Beth 1013	1950	18,000
Cron & Gracey Corp	2	stm	—	Natl 23-9-FEC	—	15,000
	4	dsl	1450	"Oilwell" 96	1290	15,000
Delta Drlg Co	20	gas-btne	1520	Emsco J-1250	1250	15,000
Buster Gardner Drlg Co Inc	1	dsl	—	Beth M-58	—	9,500
Golden Meadow Well Serv	5	dsl	725	Beth 450	—	10,000
	6	dsl	1450	Beth 1013	—	15,000
Gracey-Hellums Corp	1	stm	1000	Natl 34-10FE	1200	15,000
Harvey Drlg Co Inc	1	dsl	500	FrnksSAL-5000	500	7,500/3½"
Win Hawkins Drlg Co	5	dsl	200	Ideco PR1050	900	15,000
Loffland Bros Co	48	dsl-elec	1150	—	1026	16,000
	68	dsl	1450	—	1500	18,000
	69	dsl	1120	—	1050	18,000
	73	dsl-elec	1030	—	1200	16,000
	128	dsl	1150	—	1200	18,000
B L McFarland Drlg Corp	Bge 1	dsl	700	Brwstr N-75	—	12,000
Norton Drlg Co	Bge 1	gas-btne	800	TIW CT-5	—	9,000
	Bge 4	dsl	1400	Emsco J-1250	1500	17,000
Penrod Drlg Co	33	gas-btne	—	—	1230	12,000
	37	dsl	—	—	1000	12,000
Robstock & Reeves Drlg Co	1	dsl	1050	Wisn Sup Titan	1425	15,000
Rowan Drlg Co Inc	Bge 6	dsl-elec	1200	Emsco ED	2800	18,000
	Bge 18	stm	1800	Emsco ED	750	18,000
	Bge 26	dsl-elec	1455	Natl 100	1545	14,000
Two R Drlg Co Inc	Bge 1	dsl	1050	Wisn Titan	1425	15,000
Pointe Coupee Parish						
M M Lindsey Drlg Co	2	gas	290	Natl T-32	—	6,000
St. Charles Parish						
Bateman Drlg Co	Bge 5	dsl-elec	900	Emsco EDA 54	1000	15,000
Loffland Bros Co	39	stm	—	—	—	15,000
Rowan Drlg Co Inc	Bge 13	dsl-elec	1700	Emsco FCA	2700	18,000
St James Parish						
Justiss-Mears Oil Co Inc	8	gas	300	Emsco G-250	325	7,000/4"
C B Webster Drlg Co	8	stm	1600	Natl FE-34-10	1200+	15,000
St. Martin Parish						
Clegg & Hunt	8	dsl	—	—	1275	18,000
Delta Drlg Co	21	gas-btne	800	Natl 75	650	9,500
Harry L Edwards Drlg Co	8	stm	1000+	Natl 23-9-S	1000+	16,000
Eilers Drlg Co	2	gas-btne	375	Unit U-10	400	8,000
	3	gas-btne	580	Unit U-15	550	9,000
Falcon Seaboard Drlg Co	3	stm	1000+	Alco BIW 12	—	17,000
	34	stm	1200	Natl 3410	—	26,000
C G Glasscock Drlg Co	6	dsl	1660	Natl 110	—	16,000
Gracey-Hellums Corp	3	dsl	1775	Unit U-12-20	1800	20,000
Grey Wolf Drlg Co	3	stm	1050	Alco BIW 12	—	13,500
Loffland Bros Co	95	stm	—	—	—	18,000
Nicklos Drlg Co	11	stm	—	Natl	—	17,000
	15	gas-btne	—	Natl 80	1000	13,000
R P Phillips Well Serv	Bge 4	gas	170	Crdwll S	225	5,000
St. Mary Parish						
Brewster-Bartle Drlg Co Inc	2	dsl	—	"Oilwell" 96	1500	16,000
C G Glasscock Drlg Co	4	dsl	1700	Natl 125	—	16,000
Grey Wolf Drlg Co	4	gas-btne	585	Emsco GB-500	—	9,500
Kelly Drlg Co Inc	1	stm	600	Ideco Jr Gnt	1200	15,000
Loffland Bros Co	37	gas	1050	—	1300	15,000
	65	dsl	1420	—	1510	18,000
	76	stm	—	—	—	18,000
	81	dsl-elec	1150	—	1200	17,000
	93	stm	—	—	—	18,000
	145	dsl	1225	—	1560	14,000
Nicklos Drlg Co	18	gas-btne	—	Natl 110	1600	17,000
Norton Drlg Co	Bge 3	stm	1200+	Natl 34-62	1500	17,000
Penrod Drlg Co	28	dsl	—	—	820	9,000
R P Phillips Well Serv	Bge 1	dsl	450	Crdwll O	520	9,000
Shoreline Drlg Co Inc	Bge 5	dsl	1240	Unit U-40	1200	12,500
Wheless Drlg Co	Bge 14	dsl	1300	Emsco J-1400	1400	16,000
Texas Parish						
Gulf Coast Drlg & Expl Inc	4	dsl	800	Natl T-32	800	6,500
C A Hilburn Drlg Contr	4	gas	550	Wisn	—	10,000
Pyburn Drlg Co	1	dsl	500	Ideco M-750	750	9,000
Terrebonne Parish						
An-Son Gulf Drlg Co	4	dsl	650	Natl 75	975	11,000
Brewster-Bartle Drlg Co Inc	4	gas	—	"Oilwell" 76	—	11,000
	5	dsl	—	"Oilwell" 96	1500	16,000
	7	dsl	—	"Oilwell" 96	1500	16,000
	8	dsl	—	"Oilwell" 96	1500	16,000
	11	dsl	—	"Oilwell" 96	1500	16,000
Delta Drlg Co	11	stm	1000	Emsco UBLS-54	1690	15,000
	38	stm	530	Natl 239-S	1135	12,000
A W Eggleston Inc	1	gas-btne	410	Natl Ideal 60	560	9,800
Falcon Seaboard Drlg Co	4	stm	1000+	Whind	—	17,000
Buster Gardner Drlg Co Inc	3	dsl	—	Beth 1013	—	17,500
Kelly Drlg Co Inc	2	pwr	600	"Oilwell" 96	1500	18,000
	3	pwr	825	"Oilwell" 96	1500	18,000
Loffland Bros Co	61	stm	—	—	—	18,000
	84	stm	—	—	—	18,000
Norton Drlg Co	Bge 2	stm	1200+	Natl 34-10	1500	17,000
Penrod Drlg Co	46	dsl-elec	1250	Emsco ECB	1250	20,000
	47	dsl-elec	1250	Emsco EDA	1250	20,000

For reasons that make them the most popular tables in the world....

J&L SUPPLY recommends IDECO Rotaries



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Five sizes and ten models from 12" to 27½".

Engineered inside and out for safety. No projections, and the locking devices are positive.

You fill and gauge the oil bath reservoir at one point only. IDECO pioneered this, as they have so many rotary improvements.

Positive mud seals (neoprene) top and bottom to keep out grit.

All pinion shafts are in a capsule easily removed for repair without disturbing the table. To change table centers, install a capsule of a different size.

Fabriform steel case for greater strength and less weight.

Quiet, because all bearings are right, all parts precision made, and all materials especially developed or perfectly adapted.

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Jones & Laughlin

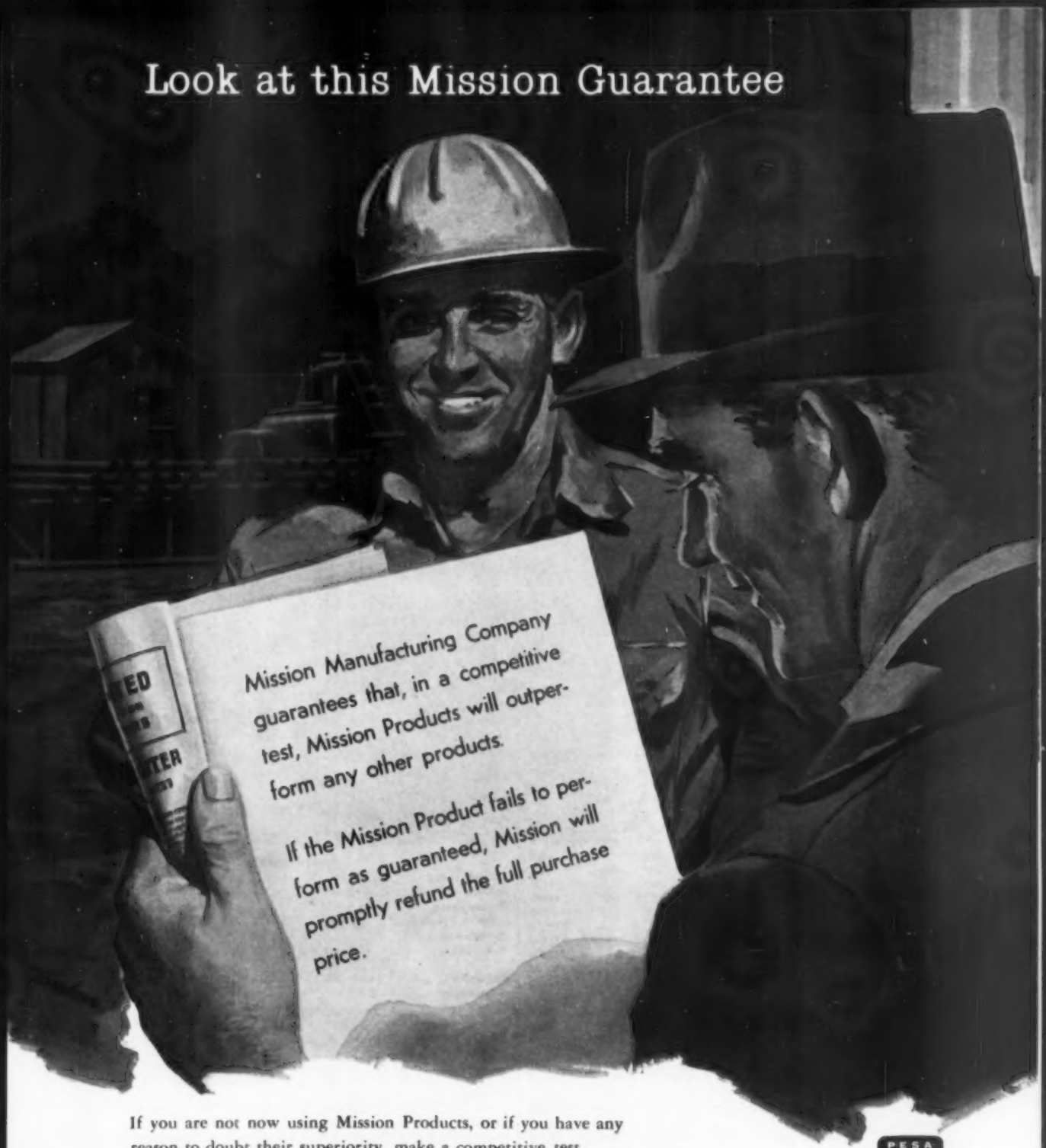
SUPPLY DIVISION – Tulsa

J&L – A GREAT NAME IN SUPPLIES

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Shoreline Drlg Co Inc	Bge 4	dsl	1860	Unit U-1220	1860	20,000
	Bge 6	dsl-elec	1700	Natl 23-9	1700	16,000
C B Webster Drlg Co	5	stm	1350	Natl FE-23-10½	1200+	15,000
Wheless Drlg Co	Bge 8	dsl	1300	Natl 130	1455	16,000
	15	dsl	1975	Natl 130	1455	16,000
Vermilion Parish						
Bullard Drlg Co Inc	2	stm	1000+	Emsco ECB	1000+	16,000
Clegg & Hunt	6	stm	—	Natl 9-DMB	—	14,000
Columbia Drlg Co	Bge 1	dsl	600	"Oilwell" 76	750	12,000
Comet Drlg Co	1	stm	1200	Ideco Big Gnt	—	16,000
Crawford Drlg Co	2	stm	—	Emsco ECA	500	15,000
Delta Drlg Co	31	gas-btne	1020	Emsco J-1000	1260	13,000
Falcon Seaboard Drlg Co	1	stm	1200+	Emsco ECA	—	25,000
	29	stm	1200+	Natl 3410	—	25,000
C J Foster Drlg Co Inc	1	stm	—	Natl	1000+	18,000
Buster Gardner Drlg Co Inc	2	dsl	—	Beth Tornado	—	15,000
Gilger Drlg Co	6	stm	1000+	Natl	1000+	15,000
Hawkins-Wilkins Prod Co	1	stm	—	Natl 3410FE	—	15,000
Loffland Bros Co	60	stm	—	—	—	15,000
	82	stm	—	—	—	15,000
Mac Drlg Co	11	stm	800+	Natl 23-9 FE	1000+	16,000
Nicklos Drlg Co	12	stm	—	Natl	—	17,000
Webster Parish						
Penrod Drlg Co	15	stm	—	—	—	15,000
	35	stm	—	—	—	15,000
	36	stm	—	—	—	14,000
Woolf & Magee Inc	8	gas-btne	1300	Beth Tornado	1300	15,000
West Feliciana Parish						
Justiss-Mears Oil Co Inc	1	gas	350	Emsco GA-500	560	10,500/4"
MARYLAND						
Prince Georges County						
Branyan Drlg Co	3	dsl	600	Wichtex E-75	145	3,000
MICHIGAN						
Allegan County						
Gordon Drlg Co	1	gas-LPG	250	"Oilwell" 64	225	4,000
Gladwin County						
Gordon Drlg Co	8	gas-LPG	600	Natl 50-A	500	7,500
	10	gas-LPG	600	"Oilwell" 66	500	8,500
Oceana County						
Lowell Bernhardt	1	dsl	300	Failing 2500	300	2,700
Saginaw County						
Gordon Drlg Co	7	gas-LPG	500	"Oilwell" 64-B	400	5,000
	11	dsl	600	Wisn Rodair	500	8,500
	12	dsl	600	Wisn Gnt	500	8,500
Wexford County						
Gordon Drlg Co	3	gas-LPG	500	"Oilwell" 64-B	400	5,000
MISSISSIPPI						
Adams County						
Dorris Ballew Inc	5	dsl	380	Unit U-15	600	7,500
Fortenbery Drlg Co Inc	1	dsl	500	Ideco H-40	300	7,500
	4	dsl	500	Ideco H-30	275	7,000
	5	dsl	500	Wisn Gnt	350	9,000
Petersen Drlg Co	4	dsl	500	Unit U-15	600	8,500
Wilson Drlg Co Inc	1	dsl	212	Ideco H-35-D	424	8,500/3½"
Clarke County						
Dorris Ballew Inc	4	dsl	760	Wisn Titan	1900	15,000
Miller Drlg Co	1	gas	—	Hou Prtble	400	7,000
Covington County						
Zach Brooks Drlg Co	8	dsl	1100	Brwstr N-95	1500	12,500
Marshall R Young Drlg Co	6	stm	2888	Natl 34	1480	16,000
Forrest County						
Dixilyn Drlg Corp	1	gas	900	Natl 75	650	12,000/3½"
	3	—	900	Natl 75	830	10,000
	12	—	740	Natl 50-A	558	8,000
Franklin County						
Sunnyland Contr Co Inc	9	dsl	—	Crdwll D	450	8,000
	12	dsl	1120	Ideco H-525 SC	1000	10,000
Greene County						
Index Drlg Co	2	dsl	1200	Unit U-40	900	13,000
Hancock County						
Marshall R Young Drlg Co	7	stm	2888	Natl 34	1480	16,000
Jefferson County						
Justiss-Mears Oil Co Inc	9	gas	650	Emsco GA-300	560	11,000/4"
Woolf & Magee Inc	11	gas-btne	275	Beth S-45	275	10,000/2⅛"
Jones County						
Index Drlg Co	3	LPG	300	Wisn Mogul	300	8,500/3½"
Lincoln County						
Marshall R Young Drlg Co	1	—	740	Natl 75	648	10,000
	8	—	945	Wisn Titan	1122	14,000
Madison County						
J B Fletcher Drlg Co	1	gas-btne	—	Unit U-15	600	7,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Pearl River County						
Crawford Drlg Co	3	stm	—	"Oilwell" 9	500	10,500
Index Drlg Co	1	LPG	250	Wisn Mogul	250	6,500/3½"
Larco Drlg Co	5	gas	1000	"Oilwell" 176	1000	10,000
Perry County						
Larco Drlg Co	4	dsl	1200	"Oilwell" 96	1200	14,000
Smith County						
Gulf Coast Drlg & Expl Inc	1	dsl	300	Natl 80-B	900	12,500
Larco Drlg Co	2	dsl	1200	"Oilwell" 96	1200	14,000
Marshall R Young Drlg Co	5	—	45	Wisn Titan	1122	14,000
	11	—	945	Wisn Titan	1122	14,000
Walthall County						
Gulf Coast Drlg & Expl Inc	2	dsl	1200	Natl 110	1200	14,000
Wayne County						
Larco Drlg Co	3	gas	750	"Oilwell" 64-B	750	8,000
Sunnyland Contr Co Inc	7	dsl	—	Ideco H-40	450	8,000
	11	dsl	—	Ideco J-750	520	11,000
Wilkinson County						
Eagle Drlg & Devl Co	2	dsl	600	Unit U-15	600	8,500
MISSOURI						
St. Louis County						
Eakle & Holder Drlg Co	1	dsl	200	Brwstr N-4	—	5,500
MONTANA						
Dawson County						
Helmerich & Payne Inc	15	dsl	700	"Oilwell" 76	1000	11,000
J D Sprecher	4	dsl	1000	Natl 80-B	1000	12,000
Fallon County						
Zach Brooks Drlg Co	6	dsl	1100	Brwstr N-75	1455	11,000
Hewit-Gulick Drlg Co	1	dsl	970	Natl 50-A	600	8,000
R L Manning Co	8	dsl	550	Emsco G-500	550	7,500
	9	dsl	550	Natl 90	550	7,500
Roden & McRae Drlg Corp	4	dsl	1175	Emsco GB-800	900	12,500
Garfield County						
Anschutz Drlg Co	12	gas	830	Brwstr N-45	530	6,500
Glacier County						
Kullberg & Otthouse Inc	1	dsl	300	Unit U-15	—	7,500
Musselshell County						
Anschutz Drlg Co Inc	3	dsl	300	Wisn Giant	280	5,000
Hose-Austin Drlg Corp	1	dsl	350	Emsco GB-250T	450	6,000
	2	dsl	250	Emsco GB-160T	250	5,000/3½"
	3	gas	450	Unit U-15	550	7,000
George Noland Drlg Co Inc	7	gas-btne	—	Emsco PDM-36	440	5,000
	11	gas-btne	—	Unit U-15	730	8,500
Pondera County						
Anschutz Drlg Co Inc	6	dsl	300	Wisn Giant	280	5,000
Roosevelt County						
Zach Brooks Drlg Co	5	dsl	800	Brwstr N-7	1182	8,500
Rosebud County						
R L Manning Co	2	gas-btne	600	Emsco 300	300	5,500
Sheridan County						
Helmerich & Payne Inc	33	gas	850	"Oilwell" 76	1100	11,000
Teton County						
M-H-O Drlg Co	8	gas-btne	800	Unit U-15	800	8,000
Wibaux County						
Hewit-Gulick Drlg Co	2	dsl	970	Natl 80	900	12,000
Roden & McRae Drlg Corp	3	dsl	1175	Emsco GB-800	900	12,500
Rowan Drlg Co Inc	5	gas-btne	840	Natl 75	1120	11,000
NEBRASKA						
Banner County						
Ashby Drlg Co Ltd	2	dsl	300	Natl T-20	300	8,000/3½"
Baird & Pfeifer Drlg Co	1	dsl	450	Unit U-15	—	9,500
Garvey Drlg Co	20	dsl	300	Wisn Mogul 42	450	7,000/3½"
Herndon Drlg Co	2	gas	600	Natl 50-A	750	10,500
Jet Drlg Co Inc	1	dsl	350	Emsco 500	450	6,500
Nebraska Drlrs Inc	1	dsl	300	Unit U-15	530	7,500
Zephyr Drlg Corp	12	dsl	258	Beth S-45-E	165	7,000/2⅛"
Cheyenne County						
Exploration Drlg Co	6	gas	310	Beth S-50	200	5,500
Dawson County						
Nemaha Oil Co	1	dsl	370	Frnks SAL 3000	370	4,500/3½"
Kimball County						
Ashby Drlg Co Ltd	1	dsl	300	Natl T-20	300	8,000/3½"
Brinkerhoff Drlg Co	11	dsl	275	Natl T-20	275	5,500
	23	dsl	375	Natl T-20	275	5,500
Garvey Drlg Co	17	dsl	300	Wisn Roadair	450	7,000/3½"
	19	dsl	300	Wisn Roadair	450	7,000/3½"
Lewis Bros Inc	1	dsl	376	Crdwll J-450	476	7,500
	2	dsl	376	Unit U-15	476	6,500
Lohmann-Johnson Drlg Co Inc	1	dsl	300	Natl 50	480	5,500
	4	dsl	300	Unit U-15	440	5,500
McDaniel Drlg Co	1	dsl	350	Ideco H-40	350	6,000

Look at this Mission Guarantee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If the Mission Product fails to perform as guaranteed, Mission will promptly refund the full purchase price.

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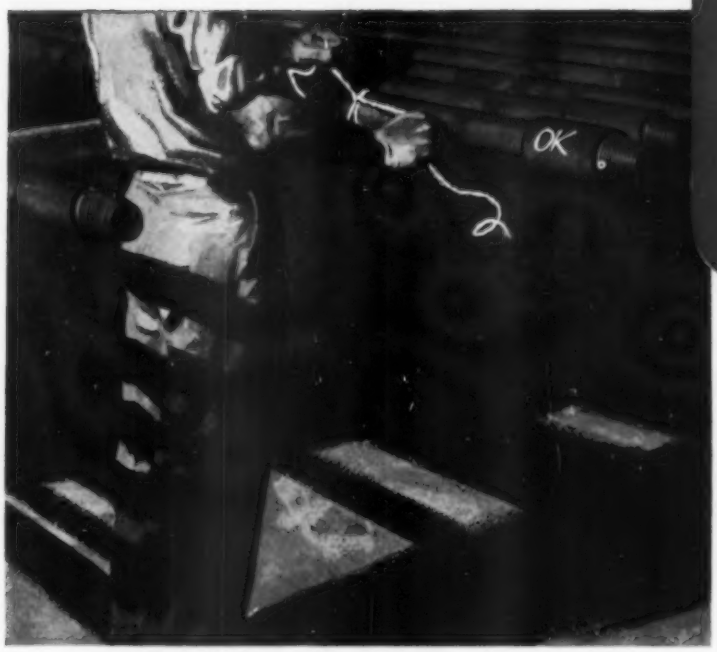
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Don M Rounds Drlg Co Inc	1	dsl	350	Natl 50	350	6,000
True Drlg Co	4	gas-gaso	400	Emsco GA-250	250	6,000
NEVADA						
Churchill County						
Barry Well Drlg Co	2	dsl	200	—	—	3,000/3½"
Eureka County						
Colorado Wyoming Drlg Co	1	dsl	300	Natl 50-A	600	9,000
Nye County						
Terminal Drlg & Prod Co	14	gas	—	Ideco H-25	105	2,000
NEW MEXICO						
Chaves County						
Triad Drlg Co	5	gas-btne	650	Beth 450	650	12,000
Eddy County						
Denver Drlg Corp	3	gas	220	Unit U-34	290	5,000
Donnell Drlg Co	14	btne	—	Ideco H-40	370	4,000
Great Western Drlg Co	12	gas-gaso	—	—	1755	16,000
	18	dsl	—	—	1200	15,000
Rowan Drlg Co Inc	9	gas-btne	900	Natl 75	1110	11,000
Tri-Service Drlg Co	5	gas	825	"Oilwell" 76	825	10,000
Urice Drlg Co	6	gas-btne	280	Wisn Super	145	3,000
S P Yates Drlg Co	2	dsl	350	Unit U-15	—	6,500
Lea County						
Cactus Drlg Corp of Tex	7	gas-btne	1275	"Oilwell" 96	1050	15,000
	10	gas-btne	700	Beth M-58	700	9,000
Coroco Drlg Co	1	gas-gaso	500	Beth 650	650	12,500
	2	gas-gaso	650	"Oilwell" 96	900	15,000
Clark Dale Drlg Co Inc	1	gas	—	"Oilwell" 76	1000	12,500
	2	gas	—	Natl 50	600	8,500
Delta Drlg Co	6	gas-btne	800	Emsco J-750	750	9,500
	9	gas-btne	936	Natl 100	800	12,000
Denver Drlg Corp	2	gas	550	Natl 50	550	8,500
	4	gas	440	Natl 50	440	8,000
Donnell Drlg Co	5	gas-btne	650	Unit U-15	650	8,000
	12	btne	400	Beth S-45-E	—	5,000
Durham Drlg Co Inc	4	gas	1250	Ideco 7-11	1450	15,000
Exploration Drlg Co	7	gas	1200	Natl 80-B	1350	13,000
Frank Frawley Drlg Co	3	gas	—	Natl 100	1050	13,000
	4	gas	—	Unit U-40	850	10,000
Frisbie Drlg Co	1	btne	450	Unit U-15	450	8,000/3½"
Helmerich & Payne Inc	25	gas	1100	"Oilwell" 96	1100	14,000
	32	gas	1100	"Oilwell" 96	1100	14,000
	43	gas	700	"Oilwell" 76	700	11,000
	44	gas	1200	"Oilwell" 96	1500	15,000
Henson Drlg Co	7	btne	275	Crdwll S	202	4,000
Johnn Drlg Co	6	gas	850	Brwstr N-95	1300	14,000
Kerr-McGee Oil Ind Inc	3	gas	870	Natl 75	832	11,500
	7	gas	900	Natl 75	818	11,500
Carl B King Drlg Co of Tex	12	gas-gaso	1000	Natl 75	1000	12,500
La Mance Drlg Co	1	btne	350	Frnks 5000	—	5,000
	5	btne	550	Unit U-15	550	7,500
Laughlin-Porter Drlg Co Inc	6	gas	1000	Wisn Titan	—	14,000
Llano Drlg Co	1	dsl	1175	"Oilwell" 96	1200	15,000
Loffland Bros Co	20	gas	1000	—	1600	20,000
Lowe Drlg Co	2	gas	750	Natl 75	—	10,000
	3	gas	1000	Natl 100	—	12,500
	4	gas	1000	Natl 125	—	12,500
	7	gas	750	Wilson	—	10,000
	9	gas	2000	Natl 125	—	17,000
	10	gas	1000	Wilson	—	12,500
McAlester Fuel Co	—	btne-gas	—	Emsco J-1250	1050	14,000
	—	btne-gas	—	Natl 100	1050	14,000
B L McFarland Inc	5	gas	700	Brwstr N-75	—	12,000
	6	gas	1000	Brwstr N-95	—	14,000
Moran Oil Prod & Drlg Corp	1	gas	—	Unit U-15	800	8,500
	2	gas	—	Natl 75	750	10,000
	4	gas	—	Unit U-34	300	5,000
Nichols Drlg Co	6	gas-btne	1050	Wisn Titan	1050	15,000
Parker Drlg Co	41	gas	—	Natl L-100	1400	14,000
	45	gas	—	Natl L-125	1400	15,000
	49	gas	—	Natl L-125	1400	15,000
	54	gas	—	Natl L-125	1400	20,000
	55	gas-elec	—	Natl L-130	2000	20,000
Rheay & Reynolds Drlg Co	6	gas	300	Wisn Giant	750	5,000
Rowan Drlg Co Inc	7	gas-btne	1260	Natl 100	1680	14,000
Schafer Drlg Co	3	gas-gaso	400	Unit U-15	600	10,000
Schoenfeld-Hunter-Kitch Drlg Co	1	LPG-gas	—	Beth 650	1000	14,000
Sharp Drlg Co	18	gas	1050	Beth MC-950	—	15,000
	34	gas	1050	Beth 1013	1200	16,000
A W Thompson Inc	2	gas	650	Beth 10-13	1500	14,000
	3	gas	650	Emsco 800	1050	11,000
	4	gas	650	Beth 810	1050	12,500
	5	gas	650	Beth 810	1050	12,500
	7	gas	650	Beth 450	1050	11,000
	9	gas	650	Clark Pr-1000	1050	12,500
	11	gas	650	Beth 450	1050	11,000
Velma Petroleum Corp	4	gas	675	Emsco GA-500	675	9,000
	5	gas	555	Emsco GA-500	555	9,000
	6	gas	450	Natl 50	450	9,000
	7	gas	330	Emsco G-300	330	6,000
Warton Drlg Co	3	gas	970	Natl 110	1600	14,000
Western Serv Drlg Co Inc	1	gas-btne	340	Natl 50	360	5,000
	10	gas-btne	1300	Beth 1013	1350	15,000
S P Yates Drlg Co	1	dsl	350	Wisn 42 Torcair	—	5,000
McKinley County						
Fleeger Drlg Inc	7	gas	360	Beth	500	5,000
Rio Arriba County						
Durham Drlg Co Inc	1	gas	500	Unit U-15	660	8,500
Empire States Drlg Corp	1	gas	225	Unit U-34 Trlr	225	5,000
	2	gas	530	Ideco H-35	530	6,500
Great Western Drlg Co	32	dsl	—	—	750	7,500
	36	gas-gaso	—	—	675	7,500
Moran Bros Inc	8	gas	700	Wisn Giant	750	10,000
	10	gas	550	Emsco GA-350	650	8,500
Sandoval County						
Great Western Drlg Co	23	dsl	—	—	800	7,500
San Juan County						
Brinkerhoff Drlg Co	24	dsl	375	Natl T-20	275	5,500
Empire States Drlg Corp	3	gas	225	Crdwll L	225	4,000
	4	gas	225	Wisn Spr	225	3,000
Foree Drlg Co	1	gas-btne	325	Unit U-34	300	4,500
	3	gas-btne	325	Unit U-15	600	7,500
Gardner Bros Drlg Co Inc	9	gas-btne	450	Unit U-15	675	7,000
	17	gas-btne	550	Natl 50-A	700	8,500
	19	gas-btne	185	Crdwll R	200	3,300
Great Western Drlg Co	20	dsl	—	—	600	5,500
Hewit-Gulick Drlg Co	3	gas	600	Natl 50-CA	900	8,000
Lemar Well Serv Corp	1	btne	260	Hopper Hoist	300	5,000
Loffland Bros Co	91	gas	600	—	640	8,000
H B Lynn Drlg Corp	1	gas-btne	700	Natl 50	—	7,500
	2	gas-btne	700	Natl 50	—	7,500
	3	gas-btne	700	Natl 50	—	7,500
Miracle-Fifer Drlg Co	3	btne	300	Unit U-34	420	6,000
Moran Bros Inc	9	gas	800	"Oilwell" 66	750	10,000
Nichols Drlg Co	3	gas-btne	700	Natl 50-A	700	9,000
Urice Drlg Co	1	gas-btne	700	Emsco GA-500	700	8,500
Union County						
Schafer Drlg Co	4	gas-gaso	200	Unit U-34	200	6,000
NEW YORK						
Schuyler County						
Gordon Drlg Co	S-7	dsl	300	Crdwll S	300	4,500
NORTH DAKOTA						
Bottineau County						
Anschutz Drlg Co Inc	5	dsl	300	Wisn Giant	280	5,000
Bowman County						
Helmerich & Payne Inc	29	gas	700	Natl 75-CA	1100	11,000
Burke County						
Calvert Drlg Inc	22	gas-btne	320	Ideco H-35	330	5,500
	23	dsl	350	Ideco H-526	600	8,500
Penrod Drlg Co	19	dsl	—	—	730	9,000
Divide County						
Calvert Drlg Co	24	gas-btne	600	Unit U-15	600	9,000
McKenzie County						
Anschutz Drlg Co Inc	14	gas	900	Brwstr N-7	600	8,500
Brinkerhoff Drlg Co	5	dsl	650	Emsco J-750	800	10,000
	17	dsl	900	Emsco GB-800	1000	12,500
	21	dsl	650	Emsco GC-500	800	10,000
Loffland Bros Co	16	gas	970	—	1260	14,000
	124	gas	870	—	960	11,000
Gabe McCall Drlg Co	3	gas	840	Natl 80	840	9,000
Penrod Drlg Co	31	dsl	—	—	1200	10,000
Rowan Drlg Co Inc	23	gas-btne	1140	Natl 75	1503	11,000
Williams County						
Exploration Drlg Co	9	gas	310	Beth S-50	250	5,500
Helmerich & Payne Inc	8	gas	600	Natl 55	800	9,000
Rowan Drlg Co Inc	15	gas-btne	1140	Natl 75	1503	11,000
OKLAHOMA						
Alfalfa County						
Barrett Petroleum Co	1	gas-gaso	—	Natl 50	450	6,800
	2	gas-gaso	—	Natl 50	450	6,800
Catline Dodson Drlg Inc	2	gas	675	Unit U-15	675	9,000
Davon Drlg Co	1	gas-LPG	250	Brwstr N-4	300	6,000
	5	gas-LPG	400	Brwstr N-45	320	7,500
Lohmann-Johnson Drlg Co Inc	S	dsl	300	Natl 32	550	7,500

Most operators have to retire some drill pipe with each well drilled . . .

Many cut their loss in half by using



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Super Shrink-Grip

Field Replaceable Tool Joints

Drill pipe failures often occur when there are many thousand feet of good service life left in the tool joints. Why lose both? With Field Replaceable Reed Super Shrink-Grip tool joints, you can retire the pipe, remove the tool joints and apply them to new pipe right in the field with your own labor. There's no costly delay, no transportation or shopping expense, and most important . . . you don't lose your original investment in the tool joints which amounts to approximately 50 percent of the cost of your drill pipe-tool joint string.

This is just one of six sound reasons why Reed Super Shrink-Grip tool joints are *right for your rig regardless of location* . . . ask your Reed man!

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Write or wire for complete information . . . or have your Reed man explain the economical and engineering advantages of Reed Tool Joints.

7080

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Viersen & Cochran	1	gas	325	Emsco G-300	—	5,800
	14	gas	325	Natl T-25	—	5,500
Webster Drlg Co	5	gas	450	Natl 50	450	7,500
Beaver County						
Arrow Drlg Co	20	gas	460	Emsco 350	—	7,000
Beckman Inc	12(wo)	gas	150	MIW P-42	175	10,000/2⅛"
Bryant-Hayward Drlg Co	1	gas	675	Natl 50	675	8,500
Garvey Drlg Co	22	dsl	300	Wisn Mogul 42	450	7,000/3½"
Helmerich & Payne Inc	36	gas	500	Emsco GB-500S2	700	9,000
Loffland Bros Co	146	gas	450	—	700	8,000
Midwestern Drillers Inc	3	dsl	370	Unit U-15	600	7,500
	4	gas	500	Emsco 500	650	8,000
Moran Bros Inc	16	gas	650	Unit U-15	700	7,500
R W Rine Drlg Co	4	dsl	520	Brwstr N-75	700	8,500
Service Drlg Co	3	LPG	650	Unit U-15	—	8,500
Unit Drlg Co	2	gas-btne	900	Unit U-15	900	8,500
Viersen & Cochran	5	gas	500	Natl 50	—	9,000
Beckham County						
Beckman Inc	17(wo)	gas	150	MIW P-42	200	10,000/2⅛"
Falcon Seaboard Drlg Co	24	gas-btne	1050	Beth 950	—	16,000
Helmerich & Payne Inc	24	gas	850	Natl 50	1100	11,000
Caddo County						
Arrow Drlg Co	1	gas	860	Ideco 1000	—	11,500
	25	gas	840	Ideco 1000	—	10,000
Big Chief Drlg Co	2	gas	1875	Natl 125	1815	16,000
C N P Drlg Co	1	gas	185	Wichtex	145	3,500
Helmerich & Payne Inc	38	gas	850	Natl 80	1100	11,000
G H Ray Well Serv	1	prop-gas	200	Wilson	200	4,500
Carter County						
Crowe Drlg Co	1	gas	175	Wisn Super 38	175	4,000
R A Davenport Drlg Contr	1	gas-btne	225	Natl T-12	185	3,500
Fain-Porter Drlg Corp	3	gas	375	Emsco GA-250	400	6,000
Flournoy-Haston Drlg Co Inc	1	gas	275	Unit U-34	200	4,500
	2	gas-btne	300	Unit U-15	650	8,500
Graves Drlg Co	1	dsl	300	Frnks 4000-A	330	3,500
Perkins Bros Drlg Co	3	gas-btne	—	Beth S-60	370	7,500
Sherin Drlg Co	2	gas-gaso	500	Unit U-15	600	8,000
Cimarron County						
Falcon Seaboard Drlg Co	23	gas-btne	300	Beth Twister	—	6,500
Cleveland County						
An-Son Drlg Co	1	gas	680	Beth MC-450	850	10,000
	2	gas	480	Unit U-15	540	7,500
Beckman Inc	18(wo)	gas	150	MIW P-42	200	10,000/2⅛"
Big X Drlg Co Inc	1	gas-gaso	750	MC-450 Beth	750	9,000
Bryant-Hayward Drlg Co	2	gas	675	Natl 50	675	8,500
	3	gas	700	Unit U-15	700	9,500
N V Duncan Drlg Co	2	gas	600	"Oilwell" 64-B	600	9,000
	4	gas	600	Natl 50-A	600	9,000
Fain-Porter Drlg Corp	1	gas	750	Wisn Titan	900	11,000
	4	gas	575	Emsco GB-500	600	8,000
Fleeger Drlg Inc	2	gas	320	Wisn Giant	700	8,500
Garr-Woolley Co	4	gas-btne	320	Emsco 500-GC	—	9,500
Kirkpatrick Oil Co	4	gas	504	Wisn Giant	504	10,500
J S Montgomery	3	gas	1100	Natl 80	1100	12,000
Dave Morgan Drlg Co	—	LPG-gas	1050	Natl 80-B	800	10,000
Nichols Drlg Co	2	gas-btne	700	Natl 55	700	12,000
	8	gas-btne	650	Natl 50-A	650	9,000
Nuckolls-Bell Co	3	dsl	600	Ideco H-525	704	9,000
O'Rourke-McGirl Drlg Corp	2	gas-btne	—	Unit U-15	800	8,000
Sherin Drlg Co	5	gas-gaso	500	Natl 55	750	9,000
Viersen & Cochran	2	gas	500	Natl 55	—	10,500
	3	gas	600	Natl 75-CA	—	10,500
Coal County						
Glendale Drlg Co	1	gas-gaso-btne	320	Unit U-10	330	5,000
Riceland Corp	4	gas	1200	Brwstr N-95	—	16,000
Comanche County						
Beard Drlg Co	1	gas-gaso-btne	450	Emsco G-450	450	7,000
Creek County						
Davon Drlg Co	4	gas-LPG	200	Brwstr N-2	290	6,500/2⅛"
R L Horn & Sons Drlg Co	1	dsl	285	Frnks Comet	300	5,500
Mesker Drlg Co	1	gas	200	Joy 300	200	2,500
Reed Drlg Co Inc	1	gas-gaso	220	Unit U-34	235	5,000
Gordon O Sams Drlg Co	2	gas-btne	185	Brwstr	185	3,000/3½"
Wade Drlg Co	3	dsl	325	Crdwll L	225	4,500
Dewey County						
Viersen & Cochran	7	gas	970	Wisn Titan	—	13,500
Ellis County						
Webster Drlg Co	3	gas	650	Wisn Atlas	650	10,000
Garfield County						
Big Chief Drlg Co	24	gas	750	Unit U-15	800	9,500
	27	gas	760	JS&G Spad Spr	760	9,000
Hayward Drlg Co	1	dsl-gas	165	Wilson	—	2,500
Lynn Drlg Co	4	gas-btne	300	Natl 50	675	8,000
Webster Drlg Co	6	gas	600	Beth	600	7,500
Wilcox Drlg Co	1	gaso	50	Failing 1500	—	1,500/2¼"
	2	gaso	50	Failing 1500	—	1,500/2¼"
Garvin County						
Berry Drlg Co	1	dsl	350	Wisn Giant	500	6,500
Dearing Inc	1	gas-btne	—	Natl 50	—	7,000
	2	gas-btne	—	Natl 100	—	15,000
Garr-Woolley Co	3	gas-btne	320	Emsco 500-GB	—	9,500
Jennings Drlg Co	5	btne-gas	450	Wisn Giant	900	9,000
Kingery Drlg Co Inc	3	dsl	210	Wilson	350	4,500
	10	btne-gas	300	Wilson	375	4,500
Parker Drlg Co	5	gas	—	Natl L-80	700	9,000
	30	gas	—	Natl L-50	700	9,000
	57	gas	—	Emsco 750	1000	10,000
Sherin Drlg Co	1	gas-gaso	500	Unit U-15	600	8,000
	4	gas-gaso	700	Natl 100	1050	12,000
Skipper Drlg Co	1	gas	325	Natl T-32	325	5,500
Triad Drlg Co	2	dsl	300	Beth S-45	300	6,000
Viersen & Cochran	4	gas	680	Natl 75	—	10,500
Dick Wegener Drlg Contr	1	dsl	300	Frnks SAL	275	5,500
Chester H Westfall Drlg Co	1	gas-gaso	625	Unit U-15	700	10,400
Grady County						
Beard Drlg Co	2	gas-gaso-btne	500	Emsco GB-500	500	8,000
Big Chief Drlg Co	29	gas	1800	Emsco 1250	1815	16,000
	30	gas	1320	Ideco 1050	1515	15,000
	32	gas	1950	Natl 110	1650	16,000
Big X Drlg Co Inc	2	gas-gaso	750	Natl 55	750	10,000
Falcon Seaboard Drlg Co	15	gas-btne	900	Unit U-20	—	16,000
	32	gas-btne	1050	Beth 650	—	16,000
General Drlg Co	5	—	300	Natl	—	7,000
Helmerich & Payne Inc	35	dsl	1100	Natl 110	1300	14,000
Parker Drlg Co	13	gas-elec	—	Natl L-34x10	1650	18,000
Viersen & Cochran	9	gas	980	Emsco J-1250	—	14,000
Dick Wegener Drlg Contr	4	gas	1900	Natl 130	1900	22,000
Chester H Westfall Drlg Co	3	gas-gaso	625	Unit U-15	700	10,400
Kidd Williams Drlg Corp	10	gas	1050	Wisn Titan	1200	18,000
Grant County						
Catline Dodson Drlg Inc	1	—	450	Beth S-45	220	5,000
Delaney Drlg Co	1	gas-btne	450	Unit U-15	450	7,500
Garvey Drlg	8	dsl	175	Wisn Giant	296	5,000
Perkins Bros Drlg Co	2	gas-btne	—	Unit U-15	675	8,500
Tennant Drlg Co	1	btne	270	Frnks 6000	450	6,000
Viersen & Cochran	6	gas	255	Natl T-25	—	5,500
	12	gas	325	Natl T-25	—	5,500
Harper County						
Beckman Inc	3(wo)	gas	150	MIW P-42	175	10,000
	19	—	180	MIW P-42	175	4,000
Calvert Drlg Inc	19	dsl	350	Unit U-15	600	8,500
	21	dsl	350	Ideco H-35	260	6,500/4"
Falcon Seaboard Drlg Co	8	gas-btne	450	Beth 450	—	10,000
	21	gas-btne	320	Unit U-15	—	8,500
Garvey Drlg Co	6	dsl	275	Unit U-15	640	8,500
Holm Drlg Co	6	dsl	750	Wisn Roadair	600	8,500
Keating Drlg Co	15	gas-gaso	—	—	675	9,000
R W Rine Drlg Co	5	gas-btne	520	Brwstr N-55	550	7,500
Schafer Drlg Co	1	gas-gaso	1200	Unit U-40	900	12,000
Sherin Drlg Co	3	gas-gaso	500	Unit U-15	600	8,000
Webster Drlg Co	7	gas	700	Unit U-15	700	8,500
Kay County						
Branyan Drlg Co	1	dsl	600	Frnks 6000	600	6,000
Fesco Inc	1	dsl	300	Brwstr N-4	300	5,000
Glenn Gillespie & Sons	7	dsl	300	Frnks 658 TRD	225	4,000
Dave Morgan Drlg Co	—	LPG-gas	350	Natl T-32	320	6,000
Moutray Drlg Co	1	btne	280	Emsco GB-160	180	4,500
Reed Drlg Co Inc	5	gas-gaso	275	Unit U-34	225	5,500
Riceland Corp	1	gas	250	Ideco H-25	—	3,000
Target Drlg Corp	1	gas-btne	225	Unit U-34	195	5,000
Kingfisher County						
Kirkpatrick Oil Co	1	gas	300	Beth S-60	258	7,500
Nuckolls-Bell Drlg Co	2	dsl	300	Ideco H-40	352	7,500
Lincoln County						
Davon Drlg Co	3	gas-LPG	500	Brwstr N-7	750	10,000
Delaney Drlg Co	2	gas-btne	225	Unit U-34	225	5,000
Austin-Dunham Inc	1	gas-btne	350	Frnks SAL-6000	570	6,000
Folk Drlg Co	1	dsl	200	Crdwll RL	200	4,000
Frizzell Drlg Co	1	gas-gaso	—	Wilson	600	7,500
Meico Drlg Co	2	btne	265	Brwstr N-35	185	5,000
Wm A Norton	1	gas-btne	300	Unit U-10	370	6,000
Reed Drlg Co Inc	4	gas-gaso	300	Unit U-34	290	5,000
Summit Drlg Corp	2	dsl	—	Frnks SAL-5000	800	5,000
Unit Drlg Co	1	gas-btne	290	Unit U-34	300	5,500
Logan County						
An-Son Drlg Co	3	gas	400	Beth Breeze	250	4,500

Dowell engineer controls the powerful Allison with remote panel.

MUD ACID

gives frac jobs a running start

For best results, fracturing fluid must enter the pay zone with enough velocity to carry its cargo of sand deep into the formation. Often, when the sand-laden fluid enters a "mudded off" formation, fluid velocity is decreased and the sand is "screened out" in the well bore. The result may be a poor fracturing job.

This situation can be avoided by using Mud Acid as a spearhead for fracturing. Mud Acid, a combination of hydrochloric and hydrofluoric acids, has the ability to dissolve or disintegrate drilling mud materials, such as bentonite. This permits fracturing fluids to enter the formation at reduced pressures and higher velocities. It also provides better distribution of the sand and increased permeability in the critical area surrounding the well bore.

Versatile Mud Acid is also used to open mud-fouled screens and liners and to free stuck drill pipe. It is an effective spearhead to clean up the well ahead of squeeze cementing operations.

For more information on the many uses of Mud Acid, call any of the 165 Dowell offices in the United States and Canada; in Venezuela contact United Oilwell Service. Or write to Dowell Incorporated, Tulsa 1, Oklahoma.

Services for the oil industry

DOWELL

A SERVICE SUBSIDIARY OF THE DOW CHEMICAL COMPANY

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Barrett Petroleum Co	4	dsl	—	Unit U-10	350	5,800
Big Chief Drlg Co	1	gas	450	JS&G Spad "Sup"	450	6,500
Blackstock & Bradley Drlg Co	3	dsl	290	Crdwll	—	4,000
Glenn Gillespie & Sons	3	dsl	425	Wisn Mogul	280	6,000
Pete Morris Drlg Co	1	dsl-gas	250	Wisn Giant	500	5,000
Love County						
Arrow Drlg Co	18	gas	1260	Emsco 1250	—	14,000
Flournoy-Haston Drlg Co Inc	3	gas	600	Wisn Atlas	750	10,000
Johnn Drlg Co	8	gas	500	Brwstr N-75	700	10,000
Ward S Merrick	1	gas	300	Wisn Giant	—	5,000
Kidd Williams Drlg Corp	5	gas	825	Wisn Atlas	900	10,000
	6	gas	925	Wisn Titan	1000	15,000
Major County						
Webster Drlg Co	4	gas	650	Emsco 500	650	8,500
Marshall County						
Holliman Drlg Co	4	gas	255	Unit U-15	500	7,500
McClain County						
Falcon Seaboard Drlg Co	28	gas	1200	Beth 650	—	16,000
Helmerich & Payne Inc	40	gas	975	"Oilwell" 96	1100	14,000
Holliman Drlg Co	5	dsl	825	Emsco GB-800	1000	11,000
Kerr-McGee Oil Ind Inc	41	gas	870	Natl 75	832	11,500
Parker Drlg Co	34	gas	—	Natl L-75	800	10,000
	37	gas	—	Natl L-100	1400	14,000
	38	gas	—	Natl L-100	1000	14,000
Perkins Bros Drlg Co	4	gas-btne	—	Beth 650	1200	12,000
Viersen & Cochran	8	gas	1200	Emsco J-1000	—	14,000
Murray County						
Riceland Corp	3	gas	300	Brwstr N-75	—	10,000
Noble County						
Barrett Petroleum Co	3	dsl	—	Wisn Giant	300	5,500
Chambless-Rosen Drlg Co	1	gas	225	Crdwll	200	5,000
Pete Morris Drlg Co	2	dsl-gas	450	Unit U-34	500	5,000
Reaves Drlg Co Inc	1	gas-btne	450	Emsco G-300	—	6,000
	2	gas-btne	550	Emsco G-450	—	7,500
	3	gas-btne	225	Emsco GB-60-T	185	4,500
Summit Drlg Corp	3	gas	—	Emsco 450	450	7,000
Nowata County						
Overby Drlg Co	3	btne	250	Mayhew 2000	250	2,000
Okfuskee County						
J & J Drlg Co	1	gas-btne	275	Beth S-45	450	4,500
Soran & Howard Drlg Co	1	gas	225	Beth	200	5,000
Oklahoma County						
Calvert Drlg Inc	18	gas-btne	350	Unit U-15	600	8,500
Sabre Drlg Co	3	dsl	285	Unit U-36	560	7,500/4"
Summit Drlg Corp	1	dsl	—	Emsco 450	480	7,000
Tommy Ward Drlg Co	3	gas	350	Unit U-15	650	8,000
Okmulgee County						
Twinoak Drlg Co	1	dsl	190	Frnks	190	3,500
Osage County						
Blackstock & Bradley Drlg Co	2	gas	325	Crdwll	—	4,000
Doak Drlg Co	2	btne-gas	233	Natl T-20	250	4,500
	3	btne-gas	233	Natl T-20	250	4,500
Dudley & Heath Drlg Co	6	dsl	265	Crdwll S	320	5,500
E & M Drlg Co	3	gas	60	Crdwll	—	2,000
	4	gas	180	Crdwll	120	2,500
Falcon Seaboard Drlg Co	19	gas-btne	185	Unit U-34	—	5,000
Garr-Woolley Co	1	gas-btne	185	Emsco 300	—	5,500
Glenn Gillespie & Sons	1	gas	360	Unit U-34	225	4,500
	6	gas	290	Unit U-34	225	4,500
John Heard & Co Inc	1	gas-LPG	240	Brwstr N-4	212	3,500
	2	gas-LPG	270	Natl T-12	212	3,500
Indian Drlg Co	1	btne	220	Ideco H-25	250	4,000
	2	dsl	220	Ideco H-35-S	350	5,000
Johnson-Bates Drlg Co	2	gas	300	Unit U-34	300	5,000
Mesker Drlg Co	2	gas	200	Joy 300	200	2,500
The Novak Drlg Co	1	gas	225	Brwstr N-4	—	3,500
	3	gas	265	Brwstr N-45	—	5,000
Peak Drlg Co Inc	12	gas-LPG	220	Natl T-12	220	4,000
	14	gas-LPG	200	Brwstr N-35	200	4,000
Reed Drlg Co	3	gas-gaso	185	Wilson	145	2,800
Gordon O Sams Drlg Co	1	gas-btne	175	Wisn Gnt	250	6,000
Service Drlg Co	2	LPG	300	Unit U-34	—	4,500
	6	dsl	320	Brwstr N-4	—	4,500
	9	dsl	320	Natl	—	4,000
Triad Drlg Co	3	gas-btne	250	Beth S-45	250	5,500
Pawnee County						
Glenn Gillespie & Sons	2	gas-dsl	360	Wisn Mogul	280	6,000
Sabre Drlg Co	2	dsl	260	Unit U-34	260	5,000/4"
Payne County						
Dudley & Heath Drlg Co	7	dsl	265	Brwstr N-4	320	5,500
Foster Drlg Co	1	dsl	265	Natl T-16	265	5,000
O'Rourke-McGirl Drlg Corp	1	gas-btne	—	Unit U-10	450	6,000
Reaves Drlg Co Inc	5	gas-btne	550	Emsco GB-250	—	6,000
Sabre Drlg Co	4	gas-LPG	225	Brwstr N-3	160	3,500/4"
Wade Drlg Co	1	dsl	225	Crdwll L	185	3,500
Pontotoc County						
Don Clawson	1	gas-btne	240	Brwstr N-4	185	3,500
Pottawatomie County						
Davon Drlg Co	2	gas-LPG	280	Brwstr N-4	320	6,500
Dearing Inc	5	gas-btne	—	Wisn Gnt	—	6,000
Garr- Woolley Co	2	gas-btne	225	Emsco 350	—	7,000
Lynn Drlg Co	1	gas-btne	300	Natl 50	450	7,000
O C Tilley Co	1	gas-LPG	325	Unit U-34	185	5,000
Kidd Williams Drlg Corp	11	gas	775	Wisn Atlas	1200	12,500
Rogers County						
Overby Drlg Co	1	dsl-btne	180	Mayhew 1000	—	1,000
Seminole County						
Austin Drlg Co	1	dsl	300	Unit U-34	300	5,500
Bodard Drlg Co	1	gas	225	Unit	185	4,500
Johnson-Bates Drlg Co	1	gas	245	Unit U-34	300	4,500
Melco Drlg Co	1	btne	265	Brwstr N-35	185	5,000
The Novak Drlg Co	2	gas	300	Unit U-10	—	6,500
Poteet Wysor & Eckles Inc	1	gas-btne	225	Unit U-34	185	5,000
R W I T Drlg Co	1	gas-LPG	150	Crdwll	150	3000/3½"
Reed Drlg Co Inc	2	gas-gaso	—	Crdwll D	410	5,500
Troup & Suttles Inc	2	gas-gaso	200	Wisn	370	5,000
Viersen & Cochran	13	gas	325	Natl T-16	—	5,200
Stephens County						
Bryant-Hayward Drlg Co	4	gas	900	Brwstr N-75	900	12,000
Crowe Drlg Co	2	gas	200	Natl T-12	175	4,000
R A Davenport Drlg Contr	2	gas-btne	145	Wichtex R-4	145	2,500
Falcon Seaboard Drlg Co	33	gas	1050	Beth 1013	—	16,000
Flournoy-Haston Drlg Co	4	gas-btne	700	Natl 100	1000	14,000
Goldsmith Drlg Co	1	—	400	Unit U-15	—	8,000
	2	—	400	Natl 50	—	8,000
Paul Hamner Drlg Co	1	gas-btne	150	Wichtex R-4	150	2,500
	2	gas-btne	350	Wisn Mogul	195	4,500
Holliman Drlg Co	1	gas	500	Unit U-15	900	7,500
Jet Drlg Co Inc	6	gas-btne	1400	Brwstr N-95	1200	15,000
Mardale Drlg Co	1	gas-gaso	185	Wichtex R-3	145	2,800
Nichols Drlg Co	1	gas-btne	350	Wisn Gnt	350	5,500
	4	gas-btne	450	Wisn Gnt	450	7,500
	9	gas-btne	700	Natl 50-A	700	10,000
	10	gas-btne	450	Wisn Gnt	450	7,500
Parker Drlg Co	56	gas	—	Natl L-50	700	9,000
Viersen & Cochran	11	gas	1525	Natl 110	—	18,500
Dick Wagener Drlg Contr	3	gas	350	Whind B-85	500	10,000
Chester H Westfall Drlg Co	2	gas-gaso	625	Unit U-15	700	10,400
Texas County						
Falcon Seaboard Drlg Co	16	gas-btne	325	Unit U-15	—	8,500
Garvey Drlg Co	18	dsl	300	Wisn Roadair	450	7,000/3½"
Helmerich & Payne Inc	46	gas	500	Emsco GB-500-52	700	9,000
Musgrove Petroleum Corp	2	dsl	495	Emsco 350	—	7,000
Nye & Snell Drlg Co	2	dsl	320	Wisn M-46	320	5,000
	4	dsl	320	Unit U-15	320	6,000
Tillman County						
Falcon Seaboard Drlg Co	27	gas-btne	185	Unit U-34	—	5,000
Tulsa County						
Riceland Corp	2	gaso	—	Failing 1500	—	1,600/2⅛"
Washita County						
Holliman Drlg Co	3	gas	255	Unit U-15	600	7,500
Nichols Drlg Co	77	gas-btne	1530	Natl 110	1530	15,000
Wagoner County						
Rud Drlg Co	3	dsl	—	—	—	5,000
Woods County						
Barrett Petroleum Co	5	gas-gaso	—	Brwstr N-7	750	8,500
Woodward County						
Big Chief Drlg Co	33	gas	1250	Natl 55	1250	11,000
Lynn Drlg Co	5	gas-btne	725	Natl 75	900	10,500
PENNSYLVANIA						
Armstrong County						
S W Jack Drlg Co	1	gas	—	Unit U-15	735	8,500
Berks County						
C S Garber & Sons Inc	—	gas-gaso	—	—	32	1,500
	—	gas-gaso	—	—	32	1,500
	—	gas-gaso	—	—	32	2,000
	23	dsl	—	Reich	—	1,200
	24	dsl	—	Ingersoll	135	130
	25	dsl	—	Ingersoll	135	400
	26	dsl	—	Ingersoll	135	130
Clearfield County						
Delta Drlg Co	24	dsl	670	Emsco GC-500	500	8,500
	29	dsl	750	Emsco J-750	750	12,000
	30	dsl	670	Emsco G-500	500	8,500
Fariman Drlg Co	1	gas-btne	500	Beth M-58	600	10,000
Lohmann-Johnson Drlg Co Inc	2	gas	500	"Oilwell" 76	750	10,000

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▶ . . . that an "Oilwell" 76 Rig with 816-P or 218-P Pumps and companion "Oilwell" equipment will give excellent service for all but the deepest drilling;

▶ . . . that an "Oilwell" 66 Rig with 218-P or 214-P Pumps and companion "Oilwell" equipment is more than adequate for work at medium depths requiring up to 550 hoisting horsepower;

▶ . . . that an "Oilwell" 52-T Rig with 214-P or 212-P Pumps and companion "Oilwell" equipment is exceptionally well-suited for mobile or portable applications and will give outstanding performance in shallow to medium drilling, representative of so much of today's operations;

▶ . . . that "Oilwell" equipment can be serviced promptly through the many branch stores adjacent to domestic oil fields or by special service representatives in foreign countries.

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USS

"OILWELL"

TRADE MARK

UNITED STATES STEEL

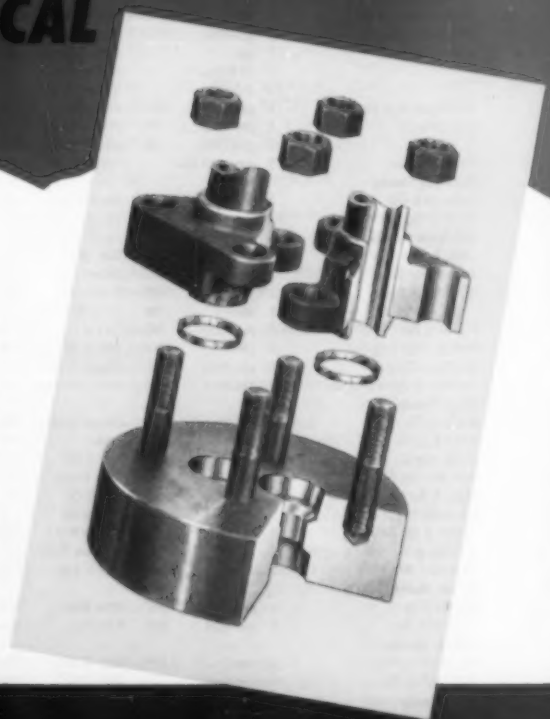
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Indiana County						
Delta Drlg Co	34	gas-btne	800	Unit U-15	600	8,000
	39	gas-btne	500	Natl 75	1000	9,500
Eakle & Holder Drlg Co	5	dsl	600	Natl 50	600	8,500
S W Jack Drlg Co	2	gas	—	Unit U-15	600	8,500
Montgomery County						
C S Garber & Sons Inc	27	dsl	—	Ingersoll 4	—	250
Westmoreland County						
Delta Drlg Co	11	dsl	560	Unit U-15	560	7,000
SOUTH DAKOTA						
Fall River County						
Ainsworth Inc	3	btne	100	Joy	100	3,000/2⅛"
Harding County						
Zach Brooks Drlg Co	3	dsl	750	Brwstr N-7	1455	8,500
TEXAS						
Anderson County						
Ace Drlg Co	2	gas	680	Emsco G-500	500	7,500
	3	gas	750	Natl 50-A	450	7,500
	4	gas	680	Emsco G-500	500	7,500
Harry Bass Drlg Co	109	stm	—	Emsco	—	14,000
Gibson Drlg Co	1	gas-btne	275	Wisn Mogul 42	265	5,000
	5	gas-btne	275	Wisn Gnt	275	6,000
Halbert Drlg Co	2	gas-btne	285	Wisn Roadair	445	6,500
Mustang Drlg Co	1	dsl	—	—	360	6,500
	2	gas-gaso	—	—	350	6,000
Andrews County						
Arrow Drlg Co	17	gas	1260	Emsco 1250	—	14,000
B B M Drlg Co	1	gas-btne	950	Emsco GB-800	1050	14,000 4"
	10	gas-btne	200	Emsco GA-500	450	7,000 3½"
L E Bever Drlg Co	1	gas	225	Unit U-34	225	5,500
Big West Drlg Co	11	gas-btne	500	Unit U-20	900	14,000
Brantley Drlg Co Inc	6	gas	400	Natl 50	750	9,000
	7	gas	675	Beth 450	1125	12,500
Cactus Drlg Corp of Tex	4	gas-btne	1050	"Oilwell" 76	1050	12,500
	5	gas-btne	700	Natl 75	700	10,000
	8	gas-btne	675	Brwstr N-7	675	9,000
Davidson Drlg Co Inc	A	gas-btne	1000	Emsco J-125D	1000	14,000
M J Delaney Co	27	gas-btne	500	Beth 450	650	11,000
	31	gas-btne	450	Wisn Gnt Rdr	600	7,000
The Denver Co	1	gas	335	Natl T-20	300	5,500
Donnell Drlg Co	6	gas-btne	975	Beth MC-450	975	10,000
	9	gas-btne	1400	Beth MC-950	1400	15,000
Empire Drlg Co	3	gas	500	Brwstr N-75	975	11,000
	7	gas	650	Wisn Titan	975	13,500
Lloyd R French Co	2	gas-btne	675	Unit U-15	600	7,500
Fryer & Hanson Drlg Co	4	gas-btne	1150	"Oilwell" 76	1200	12,000
Great Western Drlg Co	27	gas-gaso	—	—	1125	15,000
	34	dsl	—	—	1200	10,000
Helmerich & Payne Inc	41	gas	1200	Natl 110	1500	14,000
Hewgley Drlg Co	3	dsl	—	Emsco J-750	975	10,000
	5	dsl	—	Emsco J-750	975	11,000
Hondo Drlg Co	7	gas	675	Natl 55	675	11,000
Johnn Drlg Co	4	gas	375	Unit U-15	600	8,500
Keating Drlg Co	18	gas-gaso	—	—	1150	14,000
Kerr-McGee Oil Ind Inc	14	gas	575	Wisn Gnt	556	8,000
Carl B King Drlg Co of Tex	4	gas-gaso	1000	Natl 75	1000	12,500
King-Phillips Inc	1	gas-gaso	695	Natl 50	—	7,500
La Mance Drlg Co	4	btne	1050	Wisn Titan	—	13,000
Lee Drlg Co	5	gas-gaso	1050	Natl 100	—	13,000
	6	gas-gaso	1050	"Oilwell" 76	—	13,000
Llano Drlg Co	2	gas	—	Natl 100	975	14,000
Loffland Bros Co	64	gas	970	—	960	14,000
	67	gas	970	—	1050	14,000
Lowe Drlg Co	1	gas	500	Unit U-15	—	7,500
	6	gas	500	Unit U-15	—	7,500
B L McFarland Inc	10	gas	500	Brwstr N-55	—	7,000
McQueen & Stout Drlg Co	9	LPG	225	Crdwll RL	185	4,500
	15	LPG	225	Crdwll RL	185	4,500
Midland Drlg Co	1	gas-btne	600	Unit U-15	600	8,000
Milhoan Drlg Co	3	gas	900	Beth 450	—	10,000
Parker Drlg Co	4	gas	—	Natl L-100	1400	14,000
	16	gas	—	Natl L-100	1400	14,000
	39	gas	—	Natl L-100	1400	14,000
	42	gas	—	Natl L-100	1400	14,000
	47	gas	—	Natl L-100	1400	14,000
	51	gas	—	Natl 50	700	9,000
	52	gas	—	"Oilwell" 76	1400	12,500
Penrod Drlg Co	1	gas-btne	—	—	1800	15,000
Fred Pool Drlg Co	3	gas	225	Brwstr N-3	250	4,000
Schoenfeld-Hunter-KitchDrlgCo	6	LPG-gas	—	Beth 650	1000	14,000
Sharp Drlg Co	32	gas	900	Beth MC-450	—	12,000
	36	gas	1350	Beth MC-950	—	15,000
	40	gas	700	Beth Tornado	1250	14,000
A W Thompson Inc	6	gas	600	Beth 450	1050	11,000
Tri-Service Drlg Co	6	gas	1350	"Oilwell" 96	1350	16,000
	7	gas	370	Natl T-20	370	5,800
Westlund Drlg Co	1	gas-btne	600	Unit U-15	600	6,500
Zephyr Drlg Corp	10	dsl	1260	Beth Tornado	1250	15,000 4"
Aransas County						
Brewster-Bartle Drlg Co Inc	3	dsl	—	"Oilwell" 96	1500	16,000
Longhorn Drlg Corp	5	gas-btne	450	Unit U-15	675	9,000
Archer County						
Akin & Dimock	2	dsl	300	Beth S-55	420	7,000
Bolin Oil Co & D H Bolin	10	dsl	300	Wisn Giant	300	4,500
O E Hall Drlg Co	3	gas	320	Unit U-15	700	8,000
Hull Oil Co	1	btne	140	Wikr-Nr R-2	—	2,000
E W Moran Drlg Co	2	gas	500	Wisn Gnt	650	7,500
R-G Drlg Co	1	gas-gaso	—	Wilson	650	6,500
Texoma Drlg Co Inc	3	gas	225	Wisn Super	165	4,300
Atascosa County						
Harkins & Co	7	dsl	600	Unit U-15	600	8,500
Bastrop County						
R V Muckelroy & Son	1	dsl	185	Beth S-50	200	4,000
Baylor County						
Abb Drlg Co	1	gas	185	Wisn Super	145	2,500
Alan Drlg Co	1	gas	550	Wisn Giant	850	8,000
Bee County						
Allen & Morris	3	stm	500	Emsco H-46M	1200	11,000/5"
Bay City Drlg Co Inc	3	gas-btne	560	"Oilwell" 66	560	9,000
Dan L Clark Drlg Co	2	gas-btne	700	Emsco GC-500	—	7,500
Harkins & Co	4	gas-gaso	700	Wisn Giant	700	9,500
MIM Drlg Corp	1	dsl	500	Frnks SA-4500	300	5,000
Marvin S Ridgeway	—	gaso	—	Mayhew 1000	—	1,000/2⅛"
	—	gaso	—	Mayhew 1000	—	1,000/2⅛"
	—	gaso	—	Mayhew 1000	—	1,000/2⅛"
Viking Drlg Co	3	gas-gaso	500	Unit U-15	600	9,000
Borden County						
Harry Bass Drlg Co	115	gas	1200	Emsco	1200	12,000
Capitan Drlg Co	1	gas	700	Emsco GC-500	700	10,000
Cactus Drlg Corp of Tex	6	gas-btne	300	Unit U-15	—	8,500
	6	gas-btne	800	Brwstr N-75	—	12,500
Curtis & Lomax Drlg Co	11	gas-btne	300	Unit U-15	675	8,500
Denver Drlg Corp	8	gas	825	Unit U-15	825	9,500
Donnell Drlg Co	10	gas-btne	650	Beth M-58	650	10,000
O E Hall Drlg Co	2	gas	320	Unit U-15	700	8,000
Hewgley Drlg Co	1	dsl	—	Emsco GA-500	650	8,500
Loffland Bros Co	142	gas	740	—	900	9,000
Marcum Drlg Co	2	gas-btne	500	Unit U-15	675	8,000
Brazoria County						
Bass Drlg Co	2	gas-gaso-btne	675	Unit U-15	—	10,000
Harry T Bryant Drlg Co Ltd	4	gas-btne	900	Natl 75	900	12,000
Coon-Murphy Drlg Co	2	dsl	860	Ideco 700	600	11,200
C J Foster Drlg Co Inc	2	gas-LPG	—	Brwstr N-75	834	11,000
	3A	stm	—	Alco BIW 12	1000+	18,000
Liberty Drlg Corp	3	gas-btne	1000	Natl 100	—	13,000
Loffland Bros Co	56	stm	—	—	—	15,000
Rowan Drlg Co Inc	4	gas-btne	900	Natl 75	1149	11,000
Brewster County						
Durham Drlg Co Inc	3	gas	1150	Unit U-20	1300	14,000
Caldwell County						
J E Hillier	1	dsl	400	Sullivan 300-A	200	4,000/3½"
Calhoun County						
Dan L Clark Drlg Co	5	gas-btne	780	Brwstr N-7	—	8,500
Crown Rigs Inc	Bge 1	dsl	1200	Beth 1013	1200	15,000
C G Glasscock Drlg Co	7	gas	800	Unit U-15	—	9,000
Miller Bros & Bowling	2	gas-btne	800	Emsco G-450	—	8,500
Neal Drlg Co	1	gas	750	Emsco G-500	560	9,500
Southland Drlg Co	1	dsl	750	Emsco GA-350	500	9,000
Callahan County						
Wes-Tex Drlg Co	3	btne	225	Crdwll B	326	6,500
Woodson Prod Co	3	gas	300	Mayhew 3000	200	4,000
	4	dsl	600	Mayhew 5000	270	5,500
Cameron County						
Fitzpatrick Drlg Co	4	gas	1050	Beth 650	1000	13,000
Carson County						
Danforth Drlg Co	1	dsl	240	Ideco H-30	350	5,000
Graham-Michaelis Drlg Co	5	dsl	275	Crdwll B	275	4,000
Keating Drlg Co	6	gas-gaso	—	—	450	5,000
Schafer Drlg Co	7	gas-gaso	200	Ideco H-35	200	5,000
Cass County						
Glenn Drlg Co	1	dsl	200	Unit U-10	300	5,000
South States Drlg Co	2	dsl	275	Emsco CB-350	450	6,000
Chambers County						
B & G Well Maintenance	Bge 1	dsl	810	Ideco TC-600	810	10,000
Bass Drlg Co	3	gas-gaso-btne	225	Unit U-34	—	6,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Brewster-Bartle Drlg Co Inc	9	dsl	—	"Oilwell" 96	1500	16,000
Columbia Drlg Co	5	dsl	400	Unit U-15	—	7,500
Edwards & Bissett Inc	1	gas-btne	800	Wisn Gnt Roadair	800	8,500
C J Foster Drlg Co Inc	4	gas-LPG	—	Houston Prt	550	8,500
C G Glasscock Drlg Co	3	dsl	1500	Emsco J-1250	—	17,000
	5	dsl	1060	Natl 75	—	12,000
Hill Drlg Co	1	dsl-gas-btne	700	Unit U-35	370	8,000
Houston Oil Well Serv Co	2	dsl	—	Wisn Titan	1000	10,000
Mac Drlg Co	7	stm	500	Natl 34-26	5000	10,000
Rowan Drlg Co Inc	Bge 21	dsl-elec	1000	Emsco ECA	1920	12,000
Carnes W Weaver Drlg Co	1	gas-btne	700	"Oilwell"	—	10,500
Chet Whaley Well Serv Co	1	gas-gaso-btne	225	Wisn Giant	225	5,500-3½"
Cherokee County						
Robert M Bass Drlg Contr	5	gas-LPG	300	Wisn Giant	300	5,500
Gibson Drlg Co	3	gas-btne	300	Wisn Giant	275	6,000
Halbert Drlg Co	1	gas-btne	255	Wisn Torcair	285	5,500
Trant Drlg Co	3	stm	—	—	—	15,000
Woolf & Magee Inc	7	gas-btne	800	Beth MC-450	800	11,000
Childress County						
Triad Drlg Co	6	gas-btne	600	Beth M-58	600	10,000
Clay County						
Cooper Drlg Co	3	gas-btne	450	Natl 50	450	6,500
Jennings Drlg Co	6	btne-gas	350	Brwstr	350	6,000
E W Moran Drlg Co	5	gas	370	Natl 50	650	7,500
Norwood Drlg Co	1	gas-gaso	350	Wisn Gnt Rdair	600	8,500
Paine Drlg Co	6	btne	350	Wisn Giant	500	7,000
Jack L Story	5	gas-btne	450	Wisn Giant	450	7,500
Cochran County						
Empire Drlg Co	5	gas	395	Unit U-15	570	8,000
Hissom Drlg Co	2	gas	400	Unit U-34	500	6,000
M & J Inc	7	gas	269	Unit U-34	—	3,500
Western Drlg Co Inc	16	btne	450	Crdwll O	225	8,000
	21	btne	650	Natl 100	325	10,000
Coke County						
Dual Drlg Co	3	gas	600	Beth M-58	600	10,000
O'Neal Drlg Co	5	gas-gaso	—	Emsco GA-500	675	10,000
Tex-Mex Drlg Co	7	gas	—	Emsco GB-350	—	7,000
Collin County						
Holliman Drlg Co	6	gas	750	Wisn Atlas	950	10,000
Colorado County						
Bass Drlg Co	1	gas-gaso-btne	675	Unit U-15	—	10,000
Buzzini Drlg Co	5	gas-btne	900	Wisn Gnt	712	9,000
Columbia Drlg Co	2	gas	500	Unit U-15	—	8,500
Holmes Drlg Co	2	stm	—	Emsco ECA	1000+	15,000
Liberty Drlg Corp	1	gas-btne	750	Natl 75	—	10,000
Cooke County						
Alan Drlg Co	2	gas	350	Wisn Mogul	185	4,000
Brown & Martin Drlg Co	2	btne	150	Wisn	105	1,500
Felderhoff Bros Drlg Co	1	dsl	260	Wisn Mogul	220	4,700
Roy Guffey Drlg Co	5	gas btne	430	Unit U-34	260	5,500
Holliman Drlg Co	2	gas	350	Unit U-15	550	7,500
Gene McCutchin	8	gas	550	Natl 50	550	8,000
E W Moran Drlg Co	4	gas	300	Unit U-15	650	7,500
Russell & Russell Drlg & Prod Co	1	gas-gaso-btne	275	Wisn Giant	180	4,500
	2		—	Wisn Mogul	—	—
	3		350	Wisn Mogul	350	5,000
Coryell County						
McCutchen & Graham	1	btne	425	Wisn Spr Atlas	650	11,000
Cottle County						
West Central Drlg Co	5	gaso-btne	325	Unit U-15	600	7,500
Crane County						
Clark Dale Drlg Co Inc	3	gas	—	"Oilwell" 66	660	10,000
Davidson Drlg Co Inc	B	btne	630	Wisn Titan	900	10,000
Delta Drlg Co	33	gas-btne	624	Natl 50-A	450	7,000
	36	gas-btne	900	Wisn Titan	900	15,000
Durham Drlg Co Inc	2	gas	500	Unit U-15	675	9,000
Frank Frawley Drlg Co	5	gas	—	Unit U-15	675	8,500
Gardner Bros Drlg Co Inc	6	gas-btne	500	Natl 75	700	10,500
	8	gas-btne	500	Unit U-15	675	7,000
	18	gas-btne	400	Natl 50	575	7,000
Great Western Drlg Co	38	gas-gaso	—	—	675	7,500
Guadalupe Drlg Co	1	gas-btne	700	Ideco M-1000	—	10,000
Helmerich & Payne Inc	42	gas	970	Natl 100	1000	13,000
Johnn Drlg Co	7	gas	185	Brwstr N-4	300	5,500
Keating Drlg Co	16	gas-gaso	—	—	450	6,500
Laughlin-Porter Drlg Co Inc	1	gas	800	Natl 50	—	7,000
	3	gas	416	Natl T-20	—	5,000
Lee Drlg Co	1	gas-gaso	700	Natl 50	—	8,000
	2	gas-gaso	700	Natl 50	—	8,000
	4	gas-gaso	700	Natl 75	—	10,000
Lofland Bros Co	140	gas	740	—	500	9,000
Marcum Drlg Co	4	gas-btne	325	Brwstr 55-W	450	6,000
McDaniel & Boecherl Drlg Co	10	gas-gaso	—	"Oilwell" 66	—	10,000
McQueen & Stout Drlg Co	11	LPG	225	Crdwll RL	185	4,500
Milestone Drlg Co	100	dsl	550	Ideco H-525	600	7,500
Norwood Drlg Co	4	gas-gaso	500	Wisn Gnt Rdair	600	9,500
O'Neal Drlg Co	3	gas-gaso	—	Emsco 450	450	6,500
	4	gas-gaso	—	Emsco GB-500	700	11,000
Rowan Drlg Co Inc	22	gas-btne	600	Natl 50	765	7,000
B B Smith Inc	1	gas	600	Brwstr N-4	300	6,000-3½"
	2	gas	450	Unit U-15	300	5,000
Western Serv Drlg Co Inc	7	gas-btne	600	Natl 50	700	7,000
Crockett County						
Bolin Oil Co & D H Bolin	1	gas	225	Natl T-12	145	3,500
	7	gas	225	Beth S-50	185	4,500
Hewgley Drlg Co	6	dsl	—	Emsco GB-500	650	9,000
Pool & Gerlich Drlg	D-5	gas	260	Natl T-12	200	3,500
Crosby County						
Henson Drlg Co	2	btne	540	Unit U-15	540	7,500
Dawson County						
Harry Bass Drlg Co	101	gas	850	Emsco	570	9,000
Coroco Drlg Co	6	gas-gaso	400	"Oilwell" 66	500	9,000
J E Jones Drlg Co	1	gas	500	"Oilwell" 66	630	8,000
B L McFarland Inc	12	gas	500	Brwstr N-55	—	8,000
Norwood Drlg Co	3	gas-gaso	1050	Wisn Titan	1050	12,500
Russan Drlg Co	1	gas	900	Brwstr N-55	600	8,000-4½"
Denton County						
Trachta Drlg Co	1	dsl	250	Wilson	185	3,000
De Witt County						
Admiral Drlg Co Inc	E	stm	1000+	Ideco Jr Gnt	1000+	10,500
Del Mar Drlg Co	6		—	Wisn Gnt		10,000
Harkins & Co	3	gas-gaso	675	Unit U-15	675	10,000
	5	gas-gaso	675	Unit U-15	675	10,000
J & C Drlg Co	2	stm	600+	Emsco H-45	700+	9,000
Dimmit County						
Sutton Drlg Co	2	gas-gaso	—	—	125	2,500
Duval County						
Field Drlg Co	3	dsl	1040	Emsco 500	520	8,500
	4	dsl	520	Beth Breeze	260	5,500
General Well Drlg Inc	3	gas-btne	400	Beth	—	5,000
J E Hillier	2	dsl	400	Ideco H-40	400	7,000
Southland Drlg Co	4	dsl	700	Brwstr N-7	700	9,500
Eastland County						
Irish Drlg Co Inc	2	btne	280	Wichtex R-3	—	3,000
	3	btne	285	Wisn Mogul	—	4,000
	4	btne	360	Wichtex R-5	—	4,000
Ector County						
Arrow Drlg Co	24	dsl	1200	Emsco 1000	—	14,000
Robert M Bass Drlg Contr	3	gas-LPG	400	Wisn Gnt Rdair	600	8,500
Beckman Inc	1 (wo)	gas	185	Unit U-10	350	6,000
	2 (wo)	gas	185	Beth S-50	185	3,500
Brantly Drlg Co Inc	1	gas	365	Emsco 500	500	9,000
	2	gas	975	Emsco 500	1000	14,000
	4	gas	375	Beth S-55	480	6,500
	5	gas	375	Emsco 250	250	4,000
Sam E Crump Drlg Co	1	gas	—	Unit U-15	650	8,500
Davidson Drlg Co Inc	C	btne	660	Emsco GC-500	660	8,500
	D	btne	315	Wisn Gnt	600	7,500
M J Delaney Co	19	gas-btne	600	Emsco J-1250	1200	15,000
	26	stm	—	Natl T-38	—	15,000
	30	gas-btne	500	Beth 1013	1200	15,000
Delta Drlg Co	2	gas-btne	400	Natl 50	450	7,000
Dixilyn Drlg Corp	3	gas	950	Natl 100	950	14,000
Dual Drlg Co	2	dsl	400	Beth S-55	400	6,500
Eastland Oil Co	1	gas	—	—	750	10,000
	2	gas	—	—	540	7,500
Exploration Drlg Co	12	dsl	1200	Natl 125	1350	16,000
Gardner Bros Drlg Co Inc	5	gas-btne	500	Natl 75	675	9,000
	16	gas-btne	1000	Natl 125	1400	15,000
Hewgley Drlg Co	4	dsl	—	Emsco GA-500	650	8,500
Highland Drlg Co	2	gas	—	Emsco 450	500	5,600
Keating Drlg Co	11	gas-gaso	—	—	650	8,500
Carl B King Drlg Co of Tex	5	gas-gaso	1000	Natl 100	1000	13,500
	20	gas	2100	"Oilwell" 96-16	2100	20,000
Laughlin-Porter Drlg Co Inc	8	gas	—	—	—	—
Lomax Drlg Co	1	gas-btne	300	Unit U-15	650	8,500
Chas E Long Jr Inc	1	gas	200	Unit U-10	400	6,000
Milhoan Drlg Co	7	gas	600	"Oilwell" 76	—	8,000
Norwood Drlg Co	7	gas-gaso	650	Wisn	600	9,500
Parker Drlg Co	32	gas	—	Natl 50	700	9,000
	43	gas	—	"Oilwell" 96-16	1400	15,000
	46	gas	—	Natl L-75	700	10,000
	58	gas	—	Natl L-100	1400	14,000
	59	gas	—	Natl 75	1000	11,000
Rowan Drlg Co Inc	16	gas-btne	504	Natl 50	660	7,800
Schoenfeld-Hunter-Kitch Drlg Co	7	LPG-gas	—	Natl 110	1200	16,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Warton Drlg Co	2	gas	600	Natl 50	700	8,500
Western Drlg Co Inc	13	dsl	600	Crdwll O	325	9,000
	17	btne	440	Crdwll L	145	4,000
Westlund Drlg Co	7	gas-btne	650	Wisn Rdair	—	7,500
Fayette County						
Hamman Oil & Ref Co	6	dsl	250	Brwstr N-4	310	6,500
	7	dsl	340	Brwstr N-75	600	11,000
Fisher County						
Bolin Oil Co & D H Bolin	4	gas	350	Wisn Gnt	500	7,500
Dual Drlg Co	6	gas	250	Emsco GA-250T	300	5,000
General Geophysical Co	32	btne	—	—	500	7,500
Hack Drlg Co	1	btne	—	Unit U-15	412	8,500
Henson Drlg Co	5	btne	810	Unit U-15	810	7,500
J & L Drlg Co Ltd	1	dsl	—	Brwstr N-55	500	7,200
Lamar H Moore Drlg Co	1	btne	173	Crdwll RL	210	5,000
Rheay & Reynolds Drlg Co	5	gas	350	Natl 50	1200	7,000
J B Schick Drlg Co	1	btne-gas	—	Crdwll O	500	7,500
Thomas & Billups Drlg Co	2	btne	450	Emsco 300	450	6,000
West Central Drlg Co	7	gaso-btne	225	Wisn Giant	250	5,000
Fort Bend County						
C J Foster Drlg Co Inc	6	gas-LPG	—	Frnks H-37	200	6,000
Franklin County						
Big Chief Drlg Co	5	gas	1320	Emsco 1250	1515	15,000
Freestone County						
Smith & Breyer	1	btne	146	Mayhew	135	2,500
Frio County						
Appell Drlg Co	2	dsl	520	Frnks SG-101	400	7,000
Gaines County						
B B M Drlg Co	2	gas-btne	1100	Emsco GB-800	1050	14,000/4"
	5	gas-btne	450	Emsco J-750	650	12,000/3½"
	6	gas-btne	400	Emsco GB-500	650	10,000/3½"
Harry Bass Drlg Co	112	gas	1200	Emsco	1200	12,000
Robert M Bass Drlg Contr	2	gas-LPG	350	Brwstr N-45	350	7,000
Brantly Drlg Co Inc	3	gas	700	Brwstr N-75	750	11,000
Cactus Drlg Corp of Tex	1	gas-btne	1575	Natl 110	1575	15,000
M J Delaney Co	29	gas-btne	500	Beth 450	750	11,000
Dual Drlg Co	4	gas	600	Beth 450	600	11,000
Great Western Drlg Co	2	gas-gaso	—	—	840	9,000
	17	gas-gaso	—	—	1260	15,000
O E Hall Drlg Co	5	gas	700	Unit U-40	1210	12,000
Highland Drlg Co	1	gas	—	Natl 50	550	8,200
La Mance Drlg Co	2	btne	700	Unit U-15	—	9,500
	3	btne	550	"Oilwell" 64	—	6,500
Laughlin-Porter Drlg Co Inc	2	gas	740	Unit U-15	—	7,500
Chas E Long Jr Inc	3	dsl	400	Emsco GA-500	520	10,000/3½"
Lowe Drlg Co	5	gas	750	Natl 75	—	10,000
	11	gas	1250	Natl 100	—	12,500
Marcum Drlg Co	3	gas-btne	500	Emsco GA-500	700	9,000
B L McFarland Inc	8	gas	700	Brwstr N-75	—	12,000
	11	gas	1000	Natl 100	—	13,000
Moran Oil Prod & Drlg Corp	3	gas	—	Unit U-15	800	8,500
Parker Drlg Co	28	gas	—	Natl L-50	700	9,000
	33	gas	—	Natl 75	1000	11,000
	53	gas	—	Natl 75	1000	11,000
Rowan Drlg Co Inc	12	gas-btne	1260	Natl 100	1680	14,000
	25	gas-btne	1260	Natl 100	1680	14,000
Warton Drlg Co	4	gas	700	Emsco J-750	1000	12,000
Westlund Drlg Co	5	gas-btne	650	Natl 50	—	7,500
Galveston County						
Crown Rigs Inc	Bge 2	dsl	1000	Beth MC-450	1000	11,500
Houston Oil Well Serv Co	4	gas-btne	—	Ideco M-10,000	855	10,000
Penrod Drlg Co	8	gas-btne	—	—	1230	10,000
	14	gas-btne	—	—	756	10,000
	17	dsl	—	—	1464	14,000
	18	stm	—	—	—	15,000
Carnes W Weaver Drlg Co	Bge 1	dsl	2000	"Oilwell" 96	1700	16,000
Garza County						
Smith & Breyer	4	gas	230	Frnks	330	9,500
Sonic Drlg & Equip Co Inc	3	gas	300	Wichtex R-5	275	5,000
Glasscock County						
Carl B King Drlg Co of Tex	3	gas-gaso	1000	Natl 100	1000	13,500
	11	gas-gaso	900	Natl 75	900	11,000
Tri-Service Drlg Co	2	gas	675	"Oilwell" 66	675	8,500
Westlund Drlg Co	3	gas-btne	600	Unit U-15	—	6,500
Goliad County						
Appell Drlg Co	4	gas-gaso	315	Wisn Mogul	175	4,000
Boyd & Durst Drlg Contr	2	gas-btne	650	Wisn Giant	700	8,500
Miller Bros & Bowling	3	gas-btne	850	Emsco GC-500	—	9,000
Gonzales County						
Bay City Drlg Co Inc	4	gas-btne	420	Brwstr N-45	420	7,500
Gray County						
Hills & Hills Drlg Co	1	gas-btne	500	Emsco GB-350	—	6,500
Holt Bros Drlg Co	2	gas-btne	540	Ideco H-20	—	4,000
Moran Bros Inc	5	dsl	300	Wisn Giant	350	5,000
Tommy Ward Drlg Co	1	gas-btne	300	Unit U-35	426	7,000
Grayson County						
Brown & Martin Drlg Co	1	btne	230	Wisn Giant	215	5,500
Orm Drlg Co	1	dsl	600	Unit U-15	—	9,500
Gregg County						
Carter-Jones Drlg Co	8	gas-btne	—	—	500	7,500
Guadalupe County						
Travis Drlrs Inc	2	gas-btne	250	Brwstr H-3	165	3,000
Hansford County						
Arrow Drlg Co	10	gas	560	Emsco 500	—	8,000
Baker & Taylor Drlg Co	1	dsl	800	Unit U-15	800	8,000
	3	dsl	800	Unit U-15	800	8,000
Rowan Drlg Co Inc	10	gas-btne	1020	Beth 450	766	9,000
Hardin County						
CBS Workover Co	1	gas-btne	300	Ideco H-30D	215	4,500
	2	gas-btne	145	Crdwll K	145	2,500
Clegg & Hunt	2	stm	—	Emsco H-54	—	11,000
Coon-Murphy Drlg Co	1	gas	675	Frnks 137TD	340	6,700/3½"
Lusk Drlg Co	12	gas	1360	Beth M-810	1000	12,500
Mac Drlg Co	5	gas-gaso-btne	275	Beth S-45	450	5,000
Carnes W Weaver Drlg Co	2	gas-btne	900	Ideco	—	11,000
Harris County						
Admiral Drlg Co Inc	C	stm	1000+	Unit U-9	1000+	12,000
Bay City Drlg Co Inc	1	gas-btne	430	"Oilwell" 52-T	430	6,500
CBS Workover Co	3	gas-btne	300	Ideco H-30D	215	4,500
Comet Drlg Co	3	stm	900	Ideco Jr Gnt	—	10,000
Edwards & Bissett Inc	3	gas-btne	1100	Brwstr N-75	800	10,500
	6	gas-btne	600	Ideco H-40D	500	7,000
C J Foster Drlg Co Inc	8	gas-LPG	—	Wisn Gnt	366	8,000
C G Glasscock Drlg Co	8	dsl	1200	Natl 75	—	12,000
Henderson Drlg Corp	3	gas-btne	700	Natl 75	750	11,000
Housh Drlg Co	1	stm	900+	Natl	1000+	12,000
	2	stm	900+	Natl	1000+	12,000
	3	stm	800+	Emsco UBLS	800+	10,000
	5	stm	600+	Emsco UBLS	600+	8,000
	6	stm	600+	Emsco UBLS	600+	8,000
	7	stm	600+	Emsco UBLS	600+	8,000
	8	stm	600+	Emsco UBLS	600+	8,000
Liberty Drlg Corp	4	gas-btne	740	Emsco GB-500	—	9,000
Lusk Drlg Co	14	gas	600	Crdwll Trlr	380	6,500
Meadows & Walker Drlg Co	1	gas-btne	875	"Oilwell" 66	828	10,500
W L B Drlg Co	1	gas-gaso-btne	350	Brwstr N-35	165	3,500
Harrison County						
Barnwell Drlg Co Inc	4	gas	500	Wisn Giant	185	5,000
	7	dsl	600	Brwstr N-75	600	10,000
	11	dsl	800	Wisn Rdair	600	10,000
	34	dsl	800	Unit U-34	380	7,000
	45	dsl	800	Brwstr N-45	380	8,000
Robert M Bass Drlg Contr	4	gas-LPG	300	Wisn Giant	300	5,500
Lamar Drlg Corp	1	gas	420	Unit U-15	—	7,500
McGoldrick & Watson Drlg Co	1	btne	145	Brwstr N-3	140	3,500
Penrod Drlg Co	43	dsl	—	—	730	9,000
South States Drlg Co	3	dsl	330	Emsco GB-350	520	8,000/4"
Tex-Mex Drlg Co	10	gas	—	Emsco GB-500	—	9,000
Wheless Drlg Co	3	gas-btne	600	Emsco GB-350	600	7,500
Hartley County						
Urice Drlg Co	5	gas-btne	560	Wisn Giant	560	8,000
Haskell County						
Burger Drlg Co	1	gas	225	Wisn Super	185	3,500
B A Duffy Drlg Co	1	dsl	675	Frnks 3172	675	7,500/3½"
Rhodes Drlg Co	11	gas	240	Emsco 350	360	5,000
Sojourner Drlg Corp	2	dsl	320	Unit U-15	—	5,000
Hemphill County						
Baker & Taylor Drlg Co	5	gas-btne	1650	Natl 110	1650	15,000
Henderson County						
Gibson Drlg Co	4	gas-btne	226	Wisn Mogul	225	4,500
Hidalgo County						
Allen & Morris	7	dsl	500	Natl 75	900	10,000/5"
Fitzpatrick Drlg Co	1	stm	800+	Ideco	1000+	12,000
	3	dsl	775	Brwstr N-7	700	8,500
Harkins & Co	1	gas-gaso	555	Unit U-15	555	8,500
	2	dsl	300	Wisn Giant	300	6,000
Harrell Drlg Co	3	gas	700	Unit U-15	700	8,500
Hugh Kirkpatrick Inc	1	gas	696	TIW 5	712	8,000
	2	gas	1080	Natl 55-A	600	10,000
	3	gas	1090	Natl 50-A	750	9,000
Viking Drlg Co	2	dsl	475	Natl 50-A	500	8,500
Hockley County						
Arrow Drlg Co	22	dsl	1200	Emsco 1000	—	14,000
Lloyd R French Co	3	gas-btne	650	Natl 50	600	7,500
Great Western Drlg Co	37	gas-gaso	—	—	1200	10,000
Livermore Drlg Co	2	gas	500	Wisn Atlas	650	10,000

DELTA FLANGES

Make O-C-T Dual String Trees *STRONGER, LEAKPROOF, ECONOMICAL*



The unique design of O-C-T Delta Flanges has materially increased the strength and maintenance-free life of dual string trees.

Many dual string trees tend to "Y" out under pressure if they have unbalanced flanges. This stress aggravates leakage problems and often necessitates expensive extra bracing to hold the two strings together.

O-C-T Delta Flanges have solved this problem. The balanced design — plus the Laurent Seal Rings that keep pressure area at a minimum — makes possible a perfectly balanced, leak-free tree with no tendency to "Y" out.

Ask your O-C-T Representative about the many advantages of Delta Flanges or write for complete information and literature.

Best thing that ever happened to a dual string tree

O·C·T

OIL CENTER TOOL CO.

Export Representatives: South America — East West Oiltools, C. A., Del Lago Hotel, Maracaibo, Venezuela. Address Export Inquiries for All Other Countries to P. O. Box 3091, Houston, Texas.

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Loffland Bros Co	80	gas	1000	—	960	11,000
Houston County						
B G Byars Power Drlg Co	3	dsl	445	Emsco G-300	300	5,500
South States Drlg Co	1	dsl	330	Crdwll O	520	6,500
Howard County						
Harold Drlg Co	1	gaso	225	Wisn Giant	225	5,000
Thomas & Billups Drlg Co	1	btne	550	Unit U-15	590	8,000
Hunt County						
Walters Drlg Co Inc	14	gas	—	Mayhew 1000	150	400/2⅛"
Hutchinson County						
Canadian River Drlg Co	1	dsl	300	Unit U-34	300	6,000
Keating Drlg Co	13	gas-gaso	—	—	1000	12,000
Kerr-McGee Oil Ind Inc	34	dsl	300	Frnks LTX-5000	300	5,000
J R McGill	1	gas-gaso	—	Emsco	570	7,000
Schafer Drlg Co	6	gas-gaso	200	Unit U-34	200	5,000
Service Drlg Co	1	dsl	320	Unit U-34	—	4,500
	10	LPG	250	Unit U-34	—	4,000
Irion County						
Tom Bomar Well Serv	4	gas-btne	175	Crdwll AL-63	150	2,500
Fortune Drlg Corp	1	gas	325	Beth S-55C	524	7,500
Henson Drlg Co	4	btne	825	Unit U-15	825	7,500
McQueen & Stout Drlg Co	10	LPG	225	Crdwll RL	185	4,500
Tucker Drlg Co	1	gas	600	Brwstr N-55	—	9,500
Jack County						
Bolin Oil Co & D H Bolin	3	gas	350	Wisn Giant	225	5,000
Karper & Glass	3	dsl	450	Beth S-55	450	7,000
Gene McCutchin	5	gas	275	Wisn Giant	275	6,500
Paine Drlg Co	5	btne	350	Wisn Giant	450	7,000
Ward Drlg Co	2	btne	300	Wisn Giant	600	5,000
Jackson County						
C J Foster Drlg Co Inc	9	gas-LPG	—	"Oilwell" 64	412	8,000
Frio Drlg Co	3	gas-btne	350	Brwstr N-55	650	10,500
H H Howell Drlg Co	1	dsl	376	Frnks 5000	248	6,000
Chet Whaley Well Serv Co	2	gas-gaso-btne	225	Wisn Giant	275	5,500/3½"
Jeff Davis County						
Hissom Drlg Co	3	gas	450	Beth S-60	450	6,500
Jefferson County						
Admiral Drlg Co Inc	D	stm	1000+	Natl 9 DMB	1000+	12,000
Chesshir Sutton & Davis Drlg	2	gas-btne	1100	"Oilwell" 76	1200	11,500
Clegg & Hunt	3	dsl	—	Wisn Titan 56	800	11,500
	9	btne-gas	—	Natl 50-A	—	9,500
	10	btne-gas	—	Natl 50-A	—	9,500
Henderson Drlg Corp	4	gas-btne	1000	Natl B-80	1000	12,500
Lake Drlg Co	1	gas-LPG	370	Wisn Giant	—	5,800
	2	gas-LPG	180	Allis Chmrs	—	1,800
Meredith & Co	3	gas-gaso-btne	—	"Oilwell" 96	1150	13,000
Jim Hogg County						
Chiles Drlg Co	2	dsl	300	Ideco H-40	300	6,000
Milam Drlg Co	1	gas	500	Emsco G-500	500	7,500
Jim Wells County						
Allen & Morris	4	gas	400	Natl 50	400	8,500/5"
Appell Drlg Co	3	gas-gaso	510	Brwstr N-4	225	5,500
Chiles Drlg Co	1	dsl	600	Brwstr N-7	600	8,500
	3	dsl	400	Ideco H-40-D	460	7,500
Frio Drlg Inc	2	dsl	350	Unit U-15	400	6,500
General Well Drlg Inc	8	pwr	450	Unit U-34	200	5,500
Southland Drlg Co	2	gas-btne	700	Brwstr N-55	700	9,000/5"
Turnbull & Zoch Drlg Co	7	gas-btne	630	Ideco Rambler	630	10,000/3½"
Jones County						
Ace Drlg Co	1	gas	680	Emsco G-500	500	7,500
Black Drlg Co	1	dsl	275	Frnks	250	4,000/3½"
Dixon Drlg Co	1	dsl-gas	260	Natl T-20	260	5,000
Drill Well Oil Co	1	btne	185	Wisn Super	—	4,000
Fryer & Hanson Drlg Co	10	gas-btne	225	Unit U-34	275	4,500
Lauderdale & Straughan Drlg Co	2	LPG	570	Beth S-55	—	7,000
Oxford & Stasney Drlg Co	3	dsl	400	Brwstr N-4	265	5,000
H F Pettigrew Drlg Co	1	—	—	Mayhew Prtble	—	—
Sojourner Drlg Corp	5	btne	225	Natl T-8-S	—	3,250
Karnes County						
Buzzini Drlg Co	7	gas-btne	950	Wisn Atlas	930	11,000
J & C Drlg Co	8	gas-btne	800	Beth 650	800	12,000
Kenedy County						
Del Mar Drlg Co	1	stm	800+	Alco BIW-12	1000	11,000
Holmes Drlg Co	3	gas-gaso	—	Natl 110	1500	16,000
Kent County						
Edgar Davis Drlg Co	12	gas-btne	650	Wisn Giant	675	10,000
West Central Drlg Co	8	gaso-btne	325	Wisn Roadair	925	10,000
King County						
McCutchen & Graham	3	btne	350	Wisn Spr Gnt	650	9,000
Kleberg County						
C G Glasscock Drlg Co	10	dsl	750	Natl 50	—	9,000
Knox County						
Abb Drlg Co	2	gas	200	Wisn Mogul	165	3,50
T V Gorman Drlg Contr	2	dsl	300	Wisn 38 Torcair	300	4,500
I R T Drlg & Prod Co	1	btne	225	Wisn Giant	187	5,500/3½"
	3	btne	186	Wisn Super	165	3,000
Meredith Drlg Co	1	btne	225	Wisn Super	145	3,500
Norwood Drlg Co	6	gas-gaso	650	Wisn Titan	900	12,000
R Benton Ross Inc	1	dsl	210	Wilson	165	3,100
Harold Shappell Drlg Co	1	gas	245	Wichtex	145	2,800
Smith & Breyer	3	btne-dsl	55	Spencer	—	4,250
Texoma Drlg Co Inc	2	gas	225	Wisn Super	145	3,000
Lamb County						
Livermore Drlg Co	4	gas	300	Wisn Giant	350	5,000
LaSalle County						
Longhorn Drlg Co	6	gas-btne	500	"Oilwell" 76	1185	14,000
Lavaca County						
Harkins & Co	6	gas-gaso	675	Unit U-15	675	9,500
Holmes Drlg Co	7	gas-gaso	—	Beth MC-450	1000	11,000
W P Taylor Drlg Co	2	gas	—	Natl	900	11,000
Leon County						
Robert M Bass Drlg Contr	6	stm	1200	Emsco UBLS	1000+	12,500
Maxwell Herring Drlg Corp	2	gas	700	Wisn Gnt Rdair	700	10,500
	4	gas	600	Wisn Gnt Rdair	600	8,000
Liberty County						
Admiral Drlg Co Inc	F	gas-LPG	700	Wisn Giant	350	8,500
Harry T Bryant Drlg Co Ltd	3	gas-btne	700	TIW 5	600	8,000
Gilger Drlg Co	1	gas-btne	1200	Natl	1450	13,000
	2	gas-btne	400	Beth 400	400	7,500
Holmes Drlg Co	1	gas-gaso	—	Beth ML-450	1000	11,000
Housh Drlg Co	9	gas	435	Unit U-34	300	5,000
Houston Oil Well Serv Co	5	stm	1000+	Natl	1000+	12,000
Meredith & Co	1	gas-gaso-btne	—	Emsco G-500	680	9,500
Carnes W Weaver Drlg Co	5	gas-btne	465	Unit U-34	—	5,000
	6	gas-btne	540	Brwstr N-7	—	8,500
Lipscomb County						
Baker & Taylor Drlg Co	4-A	gas-btne	750	Emsco G-500	750	9,500
Lynn Drlg Co	3	gas-btne	1000	Natl 75	1000	11,500
Rowan Drlg Co Inc	2	gas-btne	840	Natl 75	1120	11,000
	31	gas-btne	900	Natl 75	1149	11,000
Webster Drlg Co	8	gas	1050	Ideco 7-11	1050	12,000
Live Oak County						
Allen & Morris	8	stm	500	Emsco UBLS-54	1200	12,500/5"
Beard Drlg Inc	1	gas-btne	500	Wisn Giant	—	5,500
A J Kuenstler Drlg Co	1	dsl	300	Wisn Giant	300	7,500
Longhorn Drlg Corp	3	stm	—	Emsco H-40	—	10,000
Martin & Holmes Oil Well Serv Co	1	dsl-gas-gaso	700	Crdwll	—	7,000
The Oil Corp	5	gas-btne	280	Crdwll Trlrig	—	6,500
Turnbull & Zoch Drlg Co	1	stm	1600	Emsco	1000+	16,000
Loving County						
Keating Drlg Co	8	gas-gaso	—	—	650	8,500
Leatherwood Drlg Co	3	dsl	220	Natl T-20	—	6,000
	5	gas	370	Wisn Roadair	—	4,000
C W McGill Drlg Co	2	gas-btne	500	Wisn Mogul	500	6,000
	3	gas-btne	500	Brwstr	500	5,000
	4	gas-btne	500	Wisn Giant	500	7,000
Lubbock County						
Marcum Drlg Co	5	gas-btne	1000	Brwstr N-95	1525	14,000
Western Drlg Co Inc	6	dsl	600	—	290	6,000
	16	dsl	600	Emsco 350	290	6,000
Lynn County						
Rhodes Drlg Co	1	gas	300	Wisn Giant	450	5,500
Madison County						
Trant Drlg Co	1	dsl	—	Unit U-15	—	9,000
Marion County						
Arrow Drlg Co	14	gas	600	Wisn	—	8,000
Carter-Jones Drlg Co	6	gas-btne	—	—	350	6,800
Matagorda County						
B B M Drlg Co	3	stm	—	Emsco UBLS-54-10	—	14,000
Bay City Drlg Co Inc	2	gas-btne	300	Unit U-34	300	5,000
Henderson Drlg Corp	5	gas-btne	800	Natl 55	800	11,000
Meadows & Walker Drlg Co	2	stm	1000	Alco BIW-12	1000+	12,000
	4	gas-btne	1455	"Oilwell" 76	1005	12,000
W P Taylor Drlg Co	3	gas	—	Natl	900	11,000
Maverick County						
Sutton Drlg Co	1	dsl	—	—	225	3,500
	3	dsl	—	—	350	6,500
	4	dsl	—	—	400	6,500
	6	dsl	—	—	225	6,000
McMullen County						
Allen & Morris	2	stm	400	Alco BIW-11	600	12,000/5"
Armstrong & Horn Drlg Co	1	dsl	450	Brwstr N-4	—	7,000
Buzzini Drlg Co	1	gas-btne	150	TIW	150	3,000
	8	gas-btne	1050	Wisn Titan	1210	13,000
Fitzpatrick Drlg Co	2	gas	950	Unit U-40	900	10,000
General Well Drlg Inc	7	dsl	450	Crdwll	450	6,500

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Longhorn Drlg Corp	4	gas-btne	450	Unit U-15	675	9,000
Pegg Bros Drlg Co	2	gas-gaso	110	—	110	3,000/3½"
Medina County						
Pegg Bros Drlg Co	1	gas-gaso	145	Brwstr	145	4,500/3½"
Menard County						
Tucker Drlg Co	5	gas	620	Crdwll O	620	9,500
Midland County						
Beckman Inc	11(wo)	gas	300	Unit U-34	300	4,500
Big West Drlg Co	17	gas-btne	600	Wisn Titan	900	13,000
Delta Drlg Co	3	gas-btne	900	Natl 100	800	12,000
Foree Drlg Co	4	gas-btne	325	Emsco GA-500	500	7,500
Great Western Drlg Co	21	gas-gaso	—	—	1260	15,000
Helmerich & Payne Inc	9	gas	1200	"Oilwell" 96	1100	14,000
Carl B King Drlg of Tex	1	gas-gaso	1000	Natl 100	1000	13,500
	10	gas-gaso	1000	Natl 75	1000	12,500
Llano Drlg Co	3	gas	—	"Oilwell" 96	975	14,000
	5	gas	—	Natl 100	1050	14,000
Lomax Drlg Co	111	gas-btne	850	Natl 75	850	10,500
Marcum Drlg Co	6	gas-btne	900	Natl 75	1050	10,000
Fred Pool Drlg Co	1	gas	580	Unit U-15	600	7,500
Rowan Drlg Co Inc	29	gas-btne	1200	Natl 100	1480	14,000
Wilbanks & Rutter Drlg Co	1	gas	675	Unit U-15	600	8,000
Zephyr Drlg Corp	3	gas	1260	Beth 950	1400	20,000/3½"
	11	gas	1260	Beth 950	1350	20,000/3½"
Mitchell County						
Hissom Drlg Co	4	gas	400	Unit U-34	350	5,000
Montague County						
Roy Guffey Drlg Co	2	gas-btne	520	Unit U-15	520	7,500
S D Johnson	11	dsl	175	Unit U-34	300	5,000
Paine Drlg Co	7	dsl	350	Wisn Giant	450	7,000
Ward Drlg Co	1	dsl	350	Wisn Titan	750	6,500
Montgomery County						
Meredith & Co	4	gas-gaso-btne	—	Brwstr N-75	850	11,500
Symons Drlg Co	U-15	gas	500	Unit U-15	600	9,500
Moore County						
Bolin Oil Co & D H Bolin	2	gas	225	Natl T-12	185	3,500
Service Drlg Co	8	LPG	300	Unit U-34		4,500
Wagner & Wyant Drlg Co Inc	3	dsl	175	Unit U-34	300	5,000
Nacogdoches County						
Robert M Bass Drlg Contr	1	gas-LPG	500	Wisn Roadair	800	10,000
Navarro County						
M J Delaney Co	21	gas-btne	500	Wisn Titan	600	9,500
Newton County						
Chessher Sutton & Davis Drlg	3	gas-btne	800	Unit U-15	700	9,000
Comet Drlg Co	2	gas-btne	825	Natl 75	750	10,000
Southland Drlg Co	3	gas-btne	835	Crdwll O	675	10,000/5"
Nolan County						
M J Delaney Co	24	gas-btne	500	Beth M-587	600	9,500
Empire Drlg Co	8	gas	500	Unit U-15	650	8,500
Foree Drlg Co	2	gas-btne	300	Unit U-15	600	7,500
Great Western Drlg Co	14	dsl	—	—	800	9,000
Roy Guffey Drlg Co	4	gas-btne	560	Unit U-15	560	7,500
	6	gas-btne	560	Unit U-15	560	7,500
Hack Drlg Co	2	btne	—	Crdwll S	161	4,500
Hondo Drlg Co	2	gas	450	Unit U-15	450	5,500
	3	gas	675	Unit U-15	675	7,500
	6	gas	450	Unit U-15	450	7,000
Marcum Drlg Co	1	gas-btne	325	Unit U-15	675	8,000
Moore & Moore Drlg Co	4	btne	175	Unit U-34	210	5,000
	6	btne	300	Unit U-15	636	9,000
Lamar H Moore Drlg Co	2	btne	250	Wisn Giant	480	7,000
	3	btne	250	Unit U-15	552	8,000
Oxford & Stasney Drlg Co	1	dsl	530	Wisn Giant	530	7,500
Schoenfeld-Hunter-Kitch Drlg Co	4	LPG-gas	—	Natl 75	800	11,000
Sojourner Drlg Corp	3	dsl	550	Unit U-15	—	7,500
Nueces County						
Del Mar Drlg Co	2	dsl	—	Natl 50	—	8,000
C G Glasscock Drlg Co	9	dsl	400	Natl T-20	—	6,000
	14	dsl	1500	Natl 75	900	12,000
Burdette Graham	1	gas-btne	738	Beth M-58	700	9,500
J & C Drlg Co	5	dsl	800	Wisn [illegible]	800	12,000
Rhodes & Hicks Drlg Corp	1	gas-btne	300	Frnks 137	—	5,500
Turnbull & Zoch Drlg Co	2	stm	1600	Ideco	1000+	14,000
Viking Drlg Co	4	gas-gaso	450	Unit U-10	500	8,500
Yarborough Drlg Co	1	dsl	780	Wisn	600	9,000
	2	gas	290	Crdwll	200	5,000
Ochiltree County						
Arrow Drlg Co	9	gas	560	Emsco 500	—	8,000
	11	dsl	595	Emsco 500	—	8,000
Baker & Taylor Drlg Co	2	dsl	800	Unit U-15	800	8,000
	6	gas-btne	750	Emsco G-450	750	9,000
	7	gas-btne	1000	Natl 55	1000	10,500
Helmerich & Payne Inc	26	gas	500	Emsco GB-500	700	9,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Loffland Bros Co	77	gas	970	—	960	11,000
Midwestern Drillers Inc	7	dsl	370	Unit U-15	750	8,500
Moran Bros Inc	1	gas	1050	Wisn Titan	1150	14,000
	4	gas	1100	Wisn Titan	1300	15,000
	6	gas	700	Wisn Giant	750	10,000
Rip C Underwood	1	gas-LPG	660	Unit U-15	660	9,500
Urice Drlg Co	2	gas-btne	840	Emsco GA-500	840	9,000
Webster Drlg Co	2	gas	600	Emsco 450	600	8,000
Oldham County						
Wagner & Wyant Drlg Co Inc	4	gas-btne	300	Unit U-15	700	9,000
Orange County						
Admiral Drlg Co Inc	G	dsl	650	Beth M-58	300	9,500
Harry T Bryant Drlg Co Ltd	2	gas-btne	700	—	600	8,000
Chessher Sutton & Davis Drlg	1	gas-btne	850	"Oilwell" 76	1050	10,500
Palo Pinto County						
Red River Drlg Co	1	dsl	200	Wichtex R-4	165	3,000
Sojourner Drlg Corp	4	btne	225	Unit U-34	—	4,500
Panola County						
Carter-Jones Drlg Co	10	gas-btne	—	—	500	7,000
Greyhound Drlg Co Inc	2	dsl	600	Brwstr N-45M	600	8,500
Maxwell Herring Drlg Corp	8	gas	300	Wisn Mogul	250	4,500
Tex-Mex Drlg Co	8	stm	—	—	1000+	9,000
Wise Drlg Account	1	gas		Unit U-15	—	7,500
	2	dsl		Beth MC-450	—	9,000
Pecos County						
Blount Drlg Corp	1	gas-btne	700	Wisn Gnt Rdair	700	8,500
	2	gas-btne	675	Unit U-15	675	8,000
	4	dsl	275	Brwstr N-4	275	5,500
Brantly Drlg Co Inc	8	gas	675	Beth 450	870	11,500
Exploration Drlg Co	14	gas	800	Natl 75-CA	900	11,000
Gardner Bros Drlg Co Inc	11	gas-btne	750	Natl 100	1050	12,500
	15	gas-btne	1000	"Oilwell" 96	1500	16,000
Great Western Drlg Co	9	dsl	—	—	1600	16,000
Helmerich & Payne Inc	39	gas	1100	"Oilwell" 96	1300	14,000
Howard C Lasiter Drlg Co	1	gas-btne	280	Brwstr N-4	340	5,000
Loffland Bros Co	75	gas	970	—	960	11,000
	99	gas	870	—	960	11,000
Parker Drlg Co	26	gas-elec	—	Natl L-10½ FE	2000	20,000
Penrod Drlg Co	12	gas-btne	—	—	1425	14,000
	32	dsl	—	—	1460	15,000
Rowan Drlg Co Inc	28	gas-btne	1200	Natl 125	1480	15,000
Sharp Drlg Co	37	gas	800	Beth MC-450	—	12,000
Potter County						
Sojourner Drlg Corp	1	btne	218	Unit U-15	—	7,500
Randall County						
Riceland Corp	5	gas	800	Brwstr N-75	—	10,000
Reagan County						
Fryer & Hanson Drlg Co	11	gas-btne	1200	Beth M-58	1200	12,000
Pool & Gerlich Drlg	D-1	gas	260	Unit U-34	300	5,000
Schoenfeld-Hunter-Kitch Drlg	9	LPG-gas	—	Natl 75	900	11,000
Sharp Drlg Co	20	gas	1350	Beth MC-950	1350	15,000
Westlund Drlg Co	6	gas-btne	975	Wisn Titan	—	12,000
Reeves County						
Denver Drlg Corp	1	gas	370	Crdwll EC	370	5,000
Great Western Drlg Co	40	gas	—	—	840	10,000
McDaniel & Beecherl Drlg Co	6	gas-gaso	—	Hou Prtble	—	5,000
O'Neal Drlg Co	1	gas-gaso	—	Beth S-45-E	200	5,500
Parker Drlg Co	44	gas	—	Natl L-125	1400	15,000
Western Serv Drlg Co Inc	2	gas-btne	600	Natl 50-A	700	8,000
	8	gas-btne	600	Beth MC-880	700	11,000
Refugio County						
Dillingham Drlg Co	1	gas-btne	530	Wisn Giant	400	7,500
Holmes Drlg Co	6	gas-gaso	—	Beth MC-450	700	10,000
J & C Drlg Co	3	gas-btne	450	Natl 50	450	7,500
	6	gas-btne	450	Natl 80	450	7,500
	7	gas-btne	700	Emsco 500	600	9,000
Meadows & Walker Drlg Co	3	gas-btne	900	Unit U-15	675	8,500
Stice Drlg Co	1	btne-gas	496	Unit U-15	—	7,500
Viking Drlg Co	1	dsl	475	Natl 80	500	8,500
Roberts County						
Loffland Bros Co	98	gas	740	—	640	8,000
Lynn Drlg Co	2	gas-btne	425	Natl 75	700	10,000
Moran Bros Inc	11	dsl	300	Wisn Giant	350	5,000
Schafer Drlg Co	9	gas-gaso	300	Ideco H-35	300	7,500
Webster Drlg Co	9	gas	—	Natl 100	1110	14,000
Runnels County						
Frank Caraway Drlg Co	1	btne-gas	225	Beth S-50	—	5,000
Roy Guffey Drlg Co	3	gas-btne	430	Unit U-34	260	5,500
Hack Drlg Co	4	btne	—	—	161	2,500
Johnn Drlg Co	2	gas	375	Unit U-15	400	7,500
	5	gas	375	Unit U-15	600	8,500
Johnson-Gadbois Drlg Co	2	gas	230	Natl T-20	—	5,500
Maxwell Drlg Co	1	btne-gas	220	Brwstr N-4	220	5,500/3½"

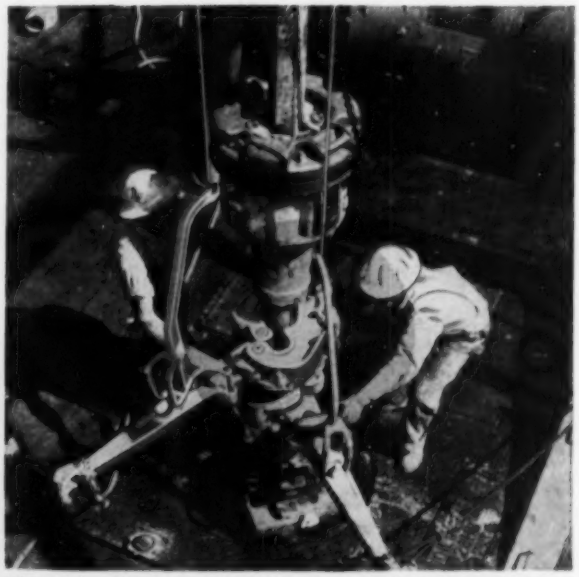
I'm trying not to blow my top, but...

one of my "tong boys" was bad hurt the other day—through no fault of his—and I'm on the warpath! ★ It happened with a set of tongs which had been repaired (?) in some field machine shop. Naturally, they weren't tested after repairing, and the first time *anybody* knew there wasn't enough clearance for them to release was when that tong-man got hurt. Do you see why I'm all burned up? Accidents like that also can give good tongs a black eye they don't deserve, and I'm real concerned about that angle too.

So, I'm going to stop right here and say a little prayer which I hope will be heard by every man in the oil patch who has anything to do with tongs—by tongmen who owe it to themselves to speak up to the driller the minute they even *think* tongs are not 100% safe—by drillers who hesitate to ride the toolpusher for safe tongs—by toolpushers who want safety for their men, even if they have to pound the desk of the man who hollers about how much drilling costs have gone up. Point out to him how compensation insurance premiums can be reduced. ★ Please, fellows, I beg you, don't try to save the few dollars it takes to *ALWAYS* be equipped with tongs that are in *TOP* condition. Stop a minute and think of the tough job tongs have to do, and you'll agree that *ONLY* the folks who make tongs should *EVER* do any repairing or rebuilding, because *nobody* is so interested in having those tongs do a safe job, and nobody *else* can repair them properly. They "magnaflux" 'em to discover cracks and hidden defects, and replace any badly worn parts with new ones; they *rebuild* slightly worn parts using the *same* accurate jigs and fixtures used to *make* those parts; machinists, heat-treaters, welders and inspectors with years of experience do a *sincere* rebuilding job to provide maximum safety for their fellow workers who will be using those tongs. That's the only way to *know* rebuilt tongs are safe, and listen how convenient it is... I'll have a set of Web Wilson FACTORY RECONDITIONED tongs right on the derrick floor *before* you give up your worn tongs. You won't have any shut-down time; no tong rentals to pay; you will have tongs to give you long, safe, satisfactory service; and they will cost you about one-half as much as new ones. How does that sound to you? Even if your worn tongs are not "Web Wilson" we will make you the same "safety first" low-cost deal. ★ Why not take a good long look at all your tongs and then talk it over with your nearest Web Wilson representative? Or, better yet, wire me COLLECT (address IKE N. SELLEM, Web Wilson Oil Tools, Inc., SBJ Compton, California) and I'll *give you some real action*. And bless you, and you, and you.

Seriously yours,

Ike N. Sellem



If you'd rather have a brand new set of WEB WILSON *Tongs, like these on a deep drilling off-shore rig—I can arrange it for you.*

I.N.S.

WEB WILSON
OIL TOOLS, INC.
LOS ANGELES/DALLAS/NEW YORK

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Moore & Moore Drlg Co	5	btne	175	Unit U-34	210	5,000
St John Drlg Co	2	gas	300	Natl 50	450	7,000
A B See Drlg Co Inc	2	gas	400	Wisn Mogul Trc	250	5,000
Tex-Mex Drlg Co	9	gas	400	Emsco 250	450	5,500
Triad Drlg Co	4	gas-btne	400	Unit U-34	400	6,500
Wes-Tex Drlg Co	5	btne	276	Natl 50	588	8,500
Rusk County						
Maxwell Herring Drlg Corp	1	gas	300	Wisn Mogul	400	6,000
Tex-Mex Drlg Co	12	gas	—	Unit U-15	—	9,000
San Jacinto County						
Admiral Drlg Co Inc	A	gas-gaso-btne	250	"Oilwell" 64-A	300	7,000
San Patricio County						
Allen & Morris	5	pwr	1100	"Oilwell" 76	780	12,000
Coastal Marine Drlg & Constr Co	2	dsl-btne	925	Ideco 800	600	9,000
Schleicher County						
Fortune Drlg Corp	2	gas	300	Unit U-15	590	7,500
Pool & Gerlich Drlg	D-2	gas	260	Unit U-34	300	5,000
Scurry County						
Calco Drlg Co	1	gas-btne	225	Mayhew 3000	200	3,500
	4	gas-btne	215	Beth Breeze	200	5,500
Dearing Inc	4	gas-btne	—	Wilson	—	4,000
Dual Drlg Co	1	gas	600	Wisn Giant	600	9,000
	5	gas	400	Emsco GA-500	400	7,000
General Geophysical Co	31	dsl	—	—	500	7,500
Layton & Newell Drlg Co	1	gas-btne	500	Unit U-15	600	8,000
Chas E Long Jr Inc	2	dsl	250	Emsco GA-500	520	10,000/3½"
McQueen & Stout Drlg Co	12	LPG	225	Crdwll RL	185	4,500
J E Miller Drlg Contr	2	btne	200	Natl T-12	165	4,000
Smith & Breyer	2	gaso	—	Cooper	—	3,000
Sonic Drlg & Equip Co Inc	2	dsl	300	Brwstr N-4	265	5,000
Shackelford County						
Bolin Oil Co & D H Bolin	5	gas	225	Wisn Mogul	190	4,000
Dearing Inc	3	gas-btne	—	Wichtex	—	3,000
Gore Drlg Co	1	dsl	640	Shovel Spl	—	7,500
	2	dsl	320	Beth	—	5,000
	3	gas	254	Joy 200-A	—	2,500/2⅛"
Red River Drlg Co	2	gas	165	Wichtex R-4	140	3,000
Varner-Neill Drlg Co	1	gas	500	Wisn Giant	450	6,000
Sherman County						
Moran Bros Inc	2	gas	700	Emsco GA-500	750	10,000
Smith County						
B G Byars Power Drlg Co	1	gas-btne	1170	Beth MC-450	775	11,000
	2	gas-btne	1145	Emsco GA-500	750	10,500
Carter-Jones Drlg Co	12	gas-btne	—	—	720	9,000
Delta Drlg Co	15	gas-btne	530	Unit U-15	600	8,000
Maxwell Herring Drlg Corp	3	gas	600	Wisn Gnt Rdair	600	9,500
Liberty Drlg Corp	2	gas-btne	675	Unit U-15	—	9,000
South States Drlg Co	4	dsl	275	Emsco GA-350	480	7,000/4"
Starr County						
Clark Fuel Prod Co	1	dsl	260	Natl T-8-S	140	2,500
	2	dsl	740	Wisn Gnt	520	8,500
Turnbull & Zoch Drlg Co	3	gas-btne	1125	Wisn Titan	1125	16,000
	5	gas-btne	850	Unit U-15	850	9,500
Stephens County						
Bolin Oil Co & D H Bolin	9	gas	185	Wisn Super	145	4,000
Ewing Drlg Co	1	btne	—	Emsco C-42	450	5,000
R-G Drlg Co	5	gas-gaso	—	Wilson	650	8,000
Tommy Ward Drlg Co	2	gas	300	Beth 350	426	7,000
Sterling County						
Brannon & Murray Drlg Co	1	gas-LPG	350	Brwstr N-55	550	7,500
Rheay & Reynolds Drlg Co	4	gas	350	Natl 50	1200	7,000
Woodson Prod Co	2	gas	600	Unit U-15	900	8,500
Stonewall County						
Dixon Drlg Co	3	gas	500	Natl 50	520	7,500
Drillers Inc	U-15	dsl	—	Unit U-15	600	7,200
Edwards Drlg Co	2	gas-gaso	600	Unit U-15	600	9,000
	3	gas-gaso	600	Unit U-15	600	9,000
Empire Drlg Co	2	gas	500	Brwstr N-7	675	9,500
Kuehn & Roberts	1	dsl	300	Wisn Giant	480	8,000
Lauderdale & Straughan Drlg Co	1	LPG	570	Wisn Titan	—	8,000
J B Schick Drlg Co	2	btne-gas	—	Crdwll O	450	7,000
Wes-Tex Drlg Co	1	btne	338	Unit U-10	326	7,500
	6	btne	675	Unit U-15	675	9,500
Sutton County						
Great Western Drlg Co	5	gas-gaso	—	—	750	7,500
	11	dsl	—	—	500	9,000
Pool & Gerlich Drlg	D-4	gas	260	Natl T-20	400	6,000
Taylor County						
Brannon & Murray Drlg Co	2	gas-LPG	350	Emsco GA-350	550	6,500
	3	gas-LPG	250	Brwstr N-4	250	5,000
J O Fox & Son	1	gas	530	Unit U-15	530	7,500
Hack Drlg Co	3	btne	—	Unit U-15	412	8,500
Henson Drlg Co	1	btne	825	Unit U-15	825	7,500
Herb Expl Co	—	gas-gaso	—	Failing 1500	—	1,750/2⅛"
	—	gas-gaso	—	Failing 1500	—	1,500/2⅛"
Johnson-Gadbois Drlg Co	1	gas	440	Wisn Gaint	440	8,000
	5	gas	410	Wisn Mogul	—	4,000
Low Drlg Co	1	btne	—	Emsco	290	7,000
J E Miller Drlg Contr	1	btne	165	Natl T-8-S	145	3,400/3½"
Norman Oil Corp	2	dsl	330	Unit U-10	350	5,000
Rhodes Drlg Co	5	gas	450	Unit U-15	675	9,000
St John Drlg Co	1	gas	400	Wisn Gnt Rd	700	8,500
A B See Drlg Co Inc	1	gas	400	Natl T-20	250	5,000
West Central Drlg Co	9	gaso-btne	225	Crdwll H	250	3,000
Wes-Tex Drlg Co	2	btne	244	Brwstr N-4	280	5,500
Terry County						
Great Western Drlg Co	4	gas	—	—	800	9,000
Dave Harlin Drlg Co	1	btne	—	Beth	—	12,000/2⅛"
Hissom Drlg Co	1	gas	600	Emsco 500	600	8,500
	6	gas	1000	Emsco A-800	1000	11,000
Carl B King Drlg Co of Tex	7	gas-gaso	1000	Natl 100	1000	13,500
Livermore Drlg Co	1	gas	870	Wisn Titan	975	12,500
	3	gas	600	Natl 75	680	10,000
Lowe Drlg Co	8	gas	1200	Natl 80	—	12,500
Milhoan Drlg Co	6	gas	600	Unit U-15	—	8,000
Throckmorton County						
Ellis & Gray	4	dsl	300	Unit U-34	300	5,000
Harvey Drlg Co	3	gas-btne	350	Wisn Mogul	400	5,000
Karper & Glass	2	gas	425	Beth C-50	425	6,000
A F Knappenberger	1	gas	350	Emsco GA-500	500	7,000
Lin-Mour Drlg Co	1	gas	315	Wisn Mogul	400	4,600
Noel Pautsky	1	dsl	300	Wisn Mogul	300	5,500
R-G Drlg Co	2	gas-gaso	—	Wilson	650	8,000
	3	gas-gaso	—	Wilson	450	6,500
Schulz & Brannan Drlg Co	1	dsl	400	Wisn Mogul	400	5,000
Sheets & Walton Drlg Co	3	pwr	365	Brwstr N-4	285	5,000
Taylor Expl Co Inc	1	btne	—	Mayhew	125	3,000
	6	gaso	—	Mayhew	—	1,000
Triad Drlg Co	1	gas-btne	500	Natl 50	500	7,000
Tom Green County						
Alvon Drlg & Expl Co	1	gas	370	Natl 50-A	450	8,500
	2	gas	740	Emsco J-750	750	12,000
J E Jones Drlg Co	3	gas	370	Natl 90	670	7,500
Frank Raiborn Drlg Co	1	gas	225	Wisn Mogul	186	4,000
Tucker Drlg Co	2	gas	425	Brwstr N-4	—	6,500
	4	dsl	610	Beth J-55	—	9,500
Trinity County						
Delta Drlg Co	17	gas-btne	1020	Emsco J-1100	1300	15,000
Tyler County						
Clegg & Hunt	7	dsl	—	Natl 75	880	11,000
Housh Drlg Co	10	gas-btne	1100	Ideco H-750	900	10,000
Upton County						
B B M Drlg Co	4	gas-btne	400	Natl 50	600	8,500/3½"
	8	gas-btne	450	Beth M-58	650	9,000/4½"
Harry Bass Drlg Co	111	gas	1200	Emsco	1200	14,000
Blount Drlg Corp	3	gas-btne	275	Unit U-34	175	5,000
Cooper Drlg Co	5	gas-btne	600	Wisn Giant	600	7,500
Gardner Bros Drlg Co Inc	10	gas-btne	750	Natl 100	1050	12,500
Helmerich & Payne Inc	37	gas	1200	"Oilwell" 96	1450	15,000
J E Jones Drlg Co	2	gas	500	Unit U-15	663	7,500
Laughlin-Porter Drlg Co Inc	4	gas	1650	Ideco 1350	—	14,000
Llano Drlg Co	4	gas	—	Natl 75	700	12,000
Norwood Drlg Co	2	gas-gaso	600	Wisn Atlas	900	10,500
Pool & Gerlich Drlg	D-3	gas	350	Emsco G-250	300	6,000
Rheay & Reynolds Drlg Co	3	gas	400	Unit U-15	1200	6,500
Tucker Drlg Co	3	gas	600	Ideco TC-600	—	9,500
Western Drlg Co Inc	14	dsl	375	Emsco 500	375	8,000
Val Verde County						
Delta Drlg Co	4	gas-btne	800	Natl 100	800	12,000
Hewgley Drlg Co	2	gas-btne	—	Ideco	1400	14,000
Rowan Drlg Co Inc	27	gas-btne	1200	Natl 125	1480	15,000
Victoria County						
Glenn Drlg Co	3	gas	145	Crdwll S	145	4,000
Miller Bros & Bowling	1	gas-btne	495	Emsco G-300	—	5,500
The Oil Corp	3	gas-btne	280	Crdwll Trlrig	—	6,500
	4	gas-btne	300	Unit U-15	—	7,500
Ward County						
Camden Drlg Co	1	dsl	300	Natl T-20	300	5,000
Eastland Oil Co	4	gas	—	—	190	4,500
Lloyd R French Co	1	gas-btne	300	Unit U-10	300	4,500
Gardner Bros Drlg Co Inc	20	gas-btne	275	Natl T-25	350	4,000
Laughlin-Porter Drlg Co Inc	5	dsl	1080	Natl 23-9FEB	—	12,000
Leatherwood Drlg Co	2	gas	440	Natl T-32	—	7,000
Lee Drlg Co	7	gas-gaso	440	Beth S-55	—	6,000
Loffland Bros Co	123	gas	1350	—	1350	14,000
McDaniel & Beecherl Drlg Co	11	gas-gaso	—	Hou Prtble	—	5,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
B L McFarland Inc	4	gas	400	Crdwll RL	—	4,500
	9	gas	400	Crdwll RL	—	4,500
Pyramid Drlg Co Inc	1	gas	370	Brwstr N-4	185	4,200/3½"
	2	dsl	320	Ideco H-30	330	6,200
Sharp Drlg Co	35	gas	1150	Beth M-810	1000	12,000
Western Serv Drlg Co Inc	13	gas-btne	550	Beth S-45-E	350	5,000
Webb County						
Field Drlg Co	2	dsl	1500	Unit U-15	1200	9,000
Wharton County						
Admiral Drlg Co Inc	8	gas-LPG	450	Crdwll O	362	9,500
Appling Drlg Co Inc	1	stm	—	—	—	8,500
	2	stm	—	—	—	9,000
	3	stm	—	—	—	10,000
Field Drlg Co	1	dsl	1040	Natl 50-A	520	8,500
Triton Drlg Co Inc	8	gas	800	Unit U-15	800	10,000/4"
Wichita County						
Jim Fish Drlg Co	1	gas	165	Wisn	140	4,000
Hale Bros Drlg Co	1	dsl	—	Whind	—	8,000
	2	gas	—	Wisn Gnt	—	6,500
	3	gas	—	Unit 34	—	4,500
Harvey Drlg Co	5	gas-btne	750	Wisn Giant	800	8,500
	6	gas-btne	500	Wisn Giant	500	7,500
Lofton Drlg Co	1	btne	300	Beth Breeze	—	5,500
Meredith Drlg Co	2	btne	500	Wisn Giant	225	7,500
Wilbarger County						
Anderson Drlg Co	1	btne	225	Wisn Mogul	—	4,000
Dublin-Kiel	1	LPG	225	Wisn Mogul	190	2,500
T V Gorman Drlg Contr	1	dsl	200	Wichtex R-3	200	3,000
Jennings Drlg Co	4	btne-gas	450	Unit U-15	600	8,000
E W Moran Drlg Co	1	gas	500	Unit U-15	560	7,500
Texoma Drlg Co Inc	1	gas	225	Wichtex R-3	145	3,000
Tibbits Drlg Co	3	gas	350	Wisn Giant	560	7,500
Wilson County						
Pegg Bros Drlg Co	3	gas-gaso	90		90	1,500/2⅞"
Sutton Drlg Co	5	gas-gaso	—	—	125	1,500
	7	dsl	—	—	225	5,000
Winkler County						
Arrow Drlg Co	23	gas	840	Wilson	—	10,000
B B M Drlg Co	9	gas-btne	1300	Unit 30	1800	18,000
Camden Drlg Co	2	dsl	600	Natl T-32	300	6,000
Coroco Drlg Co	4	gas-gaso	650	Wisn Spr Titan	900	15,000
Dixilyn Drlg Corp	4	gas	950	Natl 80	950	14,000
Frank Frawley Drlg Co	2	gas	—	Unit U-20	1050	13,000
Gardner Bros Co Inc	12	gas-btne	750	Natl 100	1050	12,500
Great Western Drlg Co	16	gas-gaso	—	—	1260	15,000
	25	gas-gaso	—	—	1125	15,000
Johnn Drlg Co	3	gas	650	Wisn Atlas	900	10,000
King-Phillips Inc	3	dsl	622	Ideco H-40D	—	5,500/4"
Laughlin-Porter Drlg Co Inc	7	gas	400	Wisn Torcair	—	5,000
Layton & Newell Drlg Co	7	stm	500	Natl 34-26-9	1000+	15,000
Loffland Bros Co	89	gas	970	—	1050	11,000
M & J Inc	14	gas	150	Crdwll RL	—	3,500
O'Neal Drlg Co	2	gas-gaso	—	Beth S-45-E	200	5,500
Rhodes & Hicks Drlg Corp	2	btne	370	Natl T-32	370	7,500
	3	btne	370	Crdwll S	185	4,500
A W Thompson Inc	8	gas	350	Beth 58	700	7,500
	12	gas	350	Emsco 350	550	5,000
Travis Drlrs Inc	1	gas-btne	325	Natl T-20	245	5,000
Western Serv Drlg Co Inc	12	dsl	250	Natl T-20	520	4,000
Wise County						
Bolin Oil Co & D H Bolin	6	gas	350	Wisn Gnt Rdair	250	6,500
Carter-Jones Drlg Co	7	gas-btne	—	—	300	6,500
	11	gas-btne	—	—	280	6,500
Graytex Drlg Co	1	gas	325	Natl T-32	350	6,500
	2	gas	325	Natl T-12	200	4,000
John W Harris Drlg Co	1	gas	500	Hou Prtble	450	6,500
	2	gas	500	Emsco GC-500	500	8,000
John Haseman Inc	1	gas-btne	350	Ideco H-35D	300	6,000
	2	gas-btne	150	Wisn Super	150	3,500
	3	gas-btne	450	Cooper	175	4,500
Leatherwood Drlg Co	1	gas	600	Ideco 750	—	10,000
McCutchen & Graham	2	btne	255	Unit U-15	570	7,500
E W Moran Drlg Co	3	dsl	285	Wisn Giant	650	7,500
Pan-Tex Drlg Co	1	gas	350	Brwstr N-45	400	6,500
Tibbits Drlg Co	2	gas	350	Wisn Giant	425	7,000
Trio Drlg Co	1	dsl-gas	520	Wisn Giant	—	8,000
	2	dsl-gas	520	Crdwll O	—	8,500
	3	gas	450	Wisn Giant	—	6,500
	4	gas	450	Natl 50	—	6,500
Walters Drlg Inc	12	dsl	—	Mayhew 1000	300	400/2⅞"
Wood County						
M J Delaney Co	25	stm	—	Emsco UBLS 54	—	15,000
	28	gas-btne	500	"Oilwell" 96	1000	14,000
Delta Drlg Co	7	stm	750	Emsco UB-54	1200	12,000
	22	gas-btne	530	Unit U-15	600	8,000
Gibson Drlg Co	2	gas-btne	226	Wisn Mogul 42	145	5,000
Trant Drlg Co	2	dsl	—	Ideco	—	12,000
Yoakum County						
Cactus Drlg Corp of Tex	3	gas-btne	800	Natl 80-B	—	12,500
Calco Drlg Co	3	gas-btne	275	Emsco GB-250-T	250	5,500
Frisbie Drlg Co	2	btne	675	Brwstr N-7	675	9,000/4"
Gardner Bros Drlg Co Inc	14	gas-btne	750	Natl 100	1050	12,500
Great Western Drlg Co	35	gas-gaso	—	—	630	7,500
Urice Drlg Co	3	gas-btne	700	Emsco GB-500	700	9,000
Western Drlg Co Inc	11	dsl	288	Emsco 350	375	6,500
	15	dsl	375	Emsco 500	375	8,000
	20	btne	325	Ideco M-10,000	325	9,000
Western Serv Drlg Co Inc	11	gas-btne	1000	Beth 810	1100	11,000
Young County						
American Drlg Corp	1	gas-btne	450	Emsco 500	450	6,000
	2	gas-btne	450	Emsco 750	450	7,500
Hamilton-Powell Drlg Co Inc	1	gas	225	Wisn Mogul	—	4,500
J W Hastings Drlg Co	4	gas-btne	330	Wisn Torcair	220	5,000
	5	gas-btne	864	Wisn Gnt Rdair	864	8,200
B M Hester	1	btne	325	Natl T-20	200	6,000
Karper & Glass	5	dsl	276	Beth S-45	276	5,500
	6	gas	276	Wilson	212	3,500
A F Knappenberger & K & H Drlg Co	2	gas	200	Wisn Mogul	400	5,000
Norwood Drlg Co	8	gas-gaso	300	Wisn	175	4,000
Oney Drlg Co	5	gas	250	Crdwll S	200	4,000
Taylor Expl Co Inc	4	gaso	—	Mayhew	75	1,000
	5	gaso	—	Mayhew	75	1,000
Zapata County						
General Well Drlg Inc	1	gas-btne	300	Brwstr N-4	300	5,000
UTAH						
Cache County						
Mountain States Drlg Co Inc	17	dsl	540	Natl T-32	—	6,000
Carbon County						
A O Bullock Drlg Co	2	gas	225	Crdwll S	—	4,000
Emery County						
Great Western Drlg Co	42	dsl	—	—	800	9,000
Garfield County						
Falcon Seaboard Drlg Co	18	dsl	700	Whind B-85	—	10,000
Grand County						
Anschutz Drlg Co Inc	4	gas	800	Wisn Giant	600	8,500
San Juan County						
Anschutz Drlg Co Inc	2	dsl	900	Wisn Giant	560	8,500
Calvert Drlg Inc	20	dsl	350	Ideco H-525	600	8,500
Camay Drlg Co Rocky Mt Div	5	gas	680	Natl 50-A	450	7,500
Carmack Drlg Co	4	dsl	472	Natl T-32	320	6,000
The Cortez Drlg Co	1	gas	300	Natl T-32	320	6,000
Exeter Drlg Co	3	btne	630	Natl 50-A	630	8,500
Exploration Drlg Co	4	gas	625	Unit U-15	600	8,000
	8	gas	670	Unit U-15	600	8,000
	10	gas	505	Unit U-15	400	8,000
	11	gas	380	Beth S-60	480	8,000
	16	gas	625	Natl 75	600	9,000
Fleeger Drlg Inc	5	gas	360	Frnks 5000	500	5,000
Great Western Drlg Co	30	gas-gaso	—	—	750	7,500
	31	gas-gaso	—	—	840	9,000
Jet Drlg Co Inc	2	dsl	600	Brwstr N-7	600	8,000
Kerr-McGee Oil Ind Inc	1	gas	825	Unit U-15	832	10,000
Loffland Bros Co	139	gas	720	—	900	9,000
R L Manning Co	4	gas-btne	600	Emsco 450	450	7,000
Moran Bros Inc	3	gas	700	Emsco GB-350	750	8,500
	7	gas	700	Wisn Giant	750	10,000
Mountain States Drlg Co Inc	6	dsl	600	Natl 50	—	7,500
George Noland Drlg Co Inc	8	gas-btne	—	Emsco GA-500	730	8,500
	9	gas-btne	—	Emsco G-500	730	8,500
Nye & Snell Drlg Co	3	dsl	500	Wisn Atlas	800	11,000
R W Rine Drlg Co	2	dsl	520	Brwstr N-7	600	8,500
	6	dsl	520	Brwstr N-75	520	8,500
Sanpete County						
Exploration Drlg Co	15	gas	800	Natl 75-CA	900	11,000
Sevier County						
Mountain States Drlg Co Inc	11	gas-dsl	1000	Natl 80-B	—	12,500
Uintah County						
Kerr-McGee Oil Ind Inc	4	gas	725	Natl 75	832	11,000
	23	gas	600	Natl 50	556	9,000
	42	gas	870	Natl 75	818	11,000
Mountain States Drlg Co Inc	4	gas-dsl	600	Emsco GB-500	—	9,000
Utah County						
Mountain States Drlg Co Inc	2	gas-dsl	1000	Emsco J-750	—	10,000

Why this pile of sand means lower drilling costs for a South Louisiana operator

The sand in this picture is part of nearly 1500 barrels that a Dorrco D-Sander removed from the mud in drilling one well in South Louisiana. Notice the sharpness of the cliff-like edges which show that the D-Sander not only removes coarse sand but also a great deal of silt and drilled clay solids.

As a result of this, pump parts last longer, bits drill faster and last longer, drilling time is reduced and the cost of mud chemicals is lower.

In one series of controlled comparisons a Dorrco D-Sander saved an average of more than 5,000 dollars per well. Because of savings like this, more and more contractors are installing Dorrco D-Sanders as standard equipment on all their rigs.

Write for Full Information.

SWACO

SALT WATER CONTROL Inc.

A Sid Richardson Development Company

1211 Ft. Worth National Bank Phone: ED 2-4434 Ft. Worth, Texas

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
WASHINGTON						
King County						
Colorado Wyoming Drlg Co	2	dsl	668	Natl 55	668	12,000
WEST VIRGINIA						
Mingo County						
Delta Drlg Co	27	dsl	380	Emsco GA-350	350	6,000
WYOMING						
Big Horn County						
Dellson Drlg Co	1	gas-btne	320	Emsco GB-500	807	8,500
	2	gas-btne	255	Emsco GA-250	320	6,000
Delta Drlg Co	18	dsl	600	Natl 75	650	9,500
True Drlg Co	9	gas-gaso	1200	Unit U-40	1200	11,000
Campbell County						
Black Hills Drlg Co Inc	1	dsl	450	Emsco GA-350	—	7,500
Bob Olds Drlg Co	1	gas	365	Emsco GB	—	7,000
Progressive Drlg Co Inc	1	gas	325	Beth Twister	550	8,000
A L Schlaikjer	1	gas	700	Wlsn Gnt Rdair	—	8,000
Converse County						
Anschutz Drlg Co Inc	11	gas	1000	Wlsn Giant	700	8,500
Black Hills Drlg Co Inc	2	dsl	1000	Emsco GA-500	—	12,000
Bueno Drlg Co	1	dsl	700	Natl T-20	270	5,000
Dellson Drlg Co	3	gas-btne	255	Emsco GB-500	540	8,000
Dyer Drlg Co	3	dsl	185	Failing 66	300	3,500
Crook County						
Bob Olds Drlg Co	3	btne	—	Natl 50	—	7,500
True Drlg Co	6	gas-gaso	500	Beth Twstr	600	8,500
	8	gas-gaso	500	Natl 50	500	7,500
	10	gas-LPG	675	Unit U-15	675	8,500
Fremont County						
Ainsworth Inc	6	btne	100	Joy	100	3,000/2⅞"
Big Horn Drlg Co Inc	1	dsl	220	—	—	4,500
Carpenter-Trant Drlg Co	6	dsl	450	Wlsn Giant	640	7,500
	7	dsl	400	Brwstr N-4	325	5,000
Kerr-McGee Oil Ind Inc	28	gas	870	Natl 75	832	11,500
R L Manning Co	11	gas-btne	1080	Emsco J-1000	1305	13,000
	15	gas-btne	540	Emsco GB-250	340	6,000
Roden & McRae Drlg Corp	1	dsl	255	Emsco GA-350	570	5,000
	2	dsl	185	Emsco GA-300	270	4,500
Taylor Expl Co Inc	8	btne	—	Failing	—	1,500
True Drlg Co	5	elec	400	Emsco H-46	400	9,000
Hot Springs County						
Anschutz Drlg Co Inc	10	dsl	800	Brwstr N-55	600	7,500
Dyer Drlg Co	1	gas-gaso	325	Natl T-32	365	6,000
George Noland Drlg Co Inc	10	gas-btne	—	Emsco PDM-36	440	5,500
Johnson County						
Anschutz Drlg Co Inc	8	gas	900	Unit U-15	600	8,500
	9	gas	800	Natl 50-A	600	8,500
Big Horn Drlg Co Inc	3	dsl	600	—	—	7,500
Laramie County						
S D Johnson	3	gas	500	Wlsn Titan 6472	900	14,000
Lincoln County						
Camay Drlg Co Rocky Mt Div	3	dsl	510	Natl 50-A	450	7,500
Natrona County						
Ainsworth Inc	4	btne	100	Joy	100	2,500/2⅞"
A O Bullock Drlg Co	3	gas	370	Beth Twstr	—	7,500
Carpenter-Trant Drlg Co	1	btne	185	Crdwll RL	185	3,000
Delta Drlg Co	28	dsl	350	Frnks SAL-6000	600	5,000
Falcon Seaboard Drlg Co	9	gas-btne	325	Unit U-15	—	8,500
Loffland Bros Co	7	dsl	970	—	960	11,000
	137	dsl	1000	—	1200	14,000
R L Manning Co	16	gas-btne	475	Natl T-32	450	6,000
Mountain States Drlg Co Inc	3	gas-dsl	600	Natl 50-A	—	7,500
Roden & McRae Drlg Corp	6	dsl	122	Frnks Rocket TD44	180	2,000
J D Sprecher	5	dsl	350	Brwstr N-45	350	6,500
True Drlg Co	7	dsl	185	Failing	165	3,500
Niobrara County						
A O Bullock Drlg Co	1	gas	225	Wichtex R5	—	3,500
George Noland Drlg Co Inc	6	gas-btne	—	Wlsn Mogul	440	4,000
Bob Olds Drlg Co	2	gas	235	Wlsn Mogul	—	6,000
Park County						
R L Manning Co	7	gas-btne	750	Emsco G-500	780	8,000
	12	gas-btne	550	Emsco GA-350	450	7,000
Mountain States Drlg Co Inc	9	gas-dsl	1400	Natl 125	—	15,000
Sublette County						
Delta Drlg Co	23	dsl	520	Emsco GA-500	500	8,000
Kent Drlg Co	—	dsl	—	Natl 50	750	7,500
Loffland Bros Co	27	gas	970	—	1100	11,000
R L Manning Co	5	gas-btne	750	Emsco G-500	750	8,000
Morrison Drlg Co Inc (Wyo)	8	dsl	175	Frnks Comet	225	5,000
Sweetwater County						
Camay Drlg Co Rocky Mt Div	1	gas	730	Unit U-15	600	8,000
Delta Drlg Co	25	gas-btne	1520	Emsco J-1250	1250	15,000
Falcon Seaboard Drlg Co	25	dsl	225	Beth Twister	—	6,500
Mountain States Drlg Co Inc	15	gas-dsl	1400	Natl 125	—	15,000
Reserve Drlg Co Inc	3	gas-gaso	500	Natl 50	500	7,500
Reserve Drlg Co Inc (Casper)	3	gas-LPG	500	Natl 50	500	7,500
Washakie County						
Anschutz Drlg Co Inc	7	gas	900	Unit U-15	600	8,500
Carpenter-Trant Drlg Co	5	dsl	900	Brwstr	900	12,000
Clark Drlg Co	—	dsl	—	Natl 50	525	6,500
Kerr-McGee Oil Ind Inc	31	gas	1000	Natl 100	1680	15,000
R L Manning Co	6	gas-btne	900	Emsco GB-800	1125	11,000
	10	gas-btne	1275	Emsco J-750	1125	11,000
Mountain States Drlg Co Inc	14	dsl	800	Ideco M-1000	—	10,000
Roden & McRae Drlg Corp	5	gas	255	Emsco GA-250 T	270	4,500
Weston County						
Bob Olds Drlg Co	4	dsl	—	Crdwll RL	—	4,000
J D Sprecher	2	dsl	900	Emsco J-750	900	9,500

U. S. Contract CABLE TOOL Drilling Rigs

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
ALABAMA						
Marion County						
Harry L Cullet	—	gas-gaso-btne	125	3000	3500	Crdwll H
	—	gas-gaso-btne	150	5000	5500	Star Spdr
	—	gas-gaso-btne	250	7000	7500	Special
ARIZONA						
Mohave County						
Aldridge & Stroud Inc	1	LPG	140	4000	5000	B Erie 36-L
ARKANSAS						
Columbia County						
E G Bradham	1	LPG-gas	145	7000	10,000	Brwstr N-4
	1	LPG-gas	180	6000	10,000	Cardwell S
Franklin County						
W C Holt Drlg Co Inc	2	gas	140	3500	4000	Wikr-Nr
Madison County						
Bennett Drlg Co	2	LPG	—	3500	4000	Star 45
CALIFORNIA						
Ventura County						
United Drlg Co	2	gas	75	2000	—	Keystone A-50
COLORADO						
Morgan County						
Signal Oilfield Serv	12	dsl	—	—	8000	Crdwll RL
Weld County						
Signal Oilfield Serv	5	dsl	200	—	8000	Crdwll RL
ILLINOIS						
Christian County						
V S & S Drlg Co	1	gas	—	—	2000	Wichtex
Clark County						
W L Dillier	1	gas	65	1500	2000	B Erie 60-L
	2	gas	65	1500	2000	B Erie 60-L
Donald P Knierim	1	gas	65	1500	2000	B Erie 60-L
Clay County						
J W Rudy	3	btne	130	—	4000	Crdwll K
Shulman Bros	1	gas-gaso	—	4000	—	Crdwll H
	2	gas-gaso	—	4000	—	Crdwll H
C W Strotman Drlg Co	2	gas	145	3600	4500	Crdwll H
Clinton County						
Perrine & Perrine Drlg Contr	2	btne	145	—	6000	B Erie 36-L
Coles County						
Cummins Drlg Co	C-6	gas-gaso	78	2500	3500	B Erie 28-L

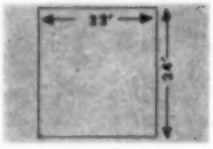
NEW! 98 and 132-ft. JUNIOR *Full-View Masts* by IDECO

Triangular cross-section columns have extra stability

Triangular design gives maximum resistance to damage in field handling. Compact nesting for economical moves.

Complete visibility makes round trips faster, safer

Driller has a "Full-View" of derrick man and traveling block, permitting faster hoisting and safer control.

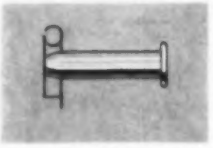


Roomy 22 x 24-ft. working floor clear of obstructions

Cathead areas are completely free of obstructions. Working floor is clear from drawworks to pipe ramp.

300,000 lbs. hook load capacity with eight lines

Complete strain gauge tests under maximum loaded conditions prove reserve strength of the Jr. Full-View.

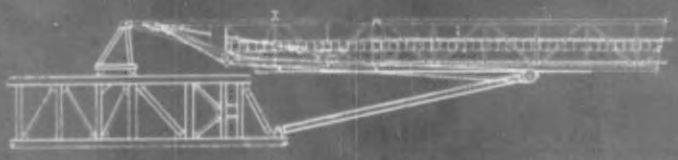


Pin connections throughout the mast and substructure

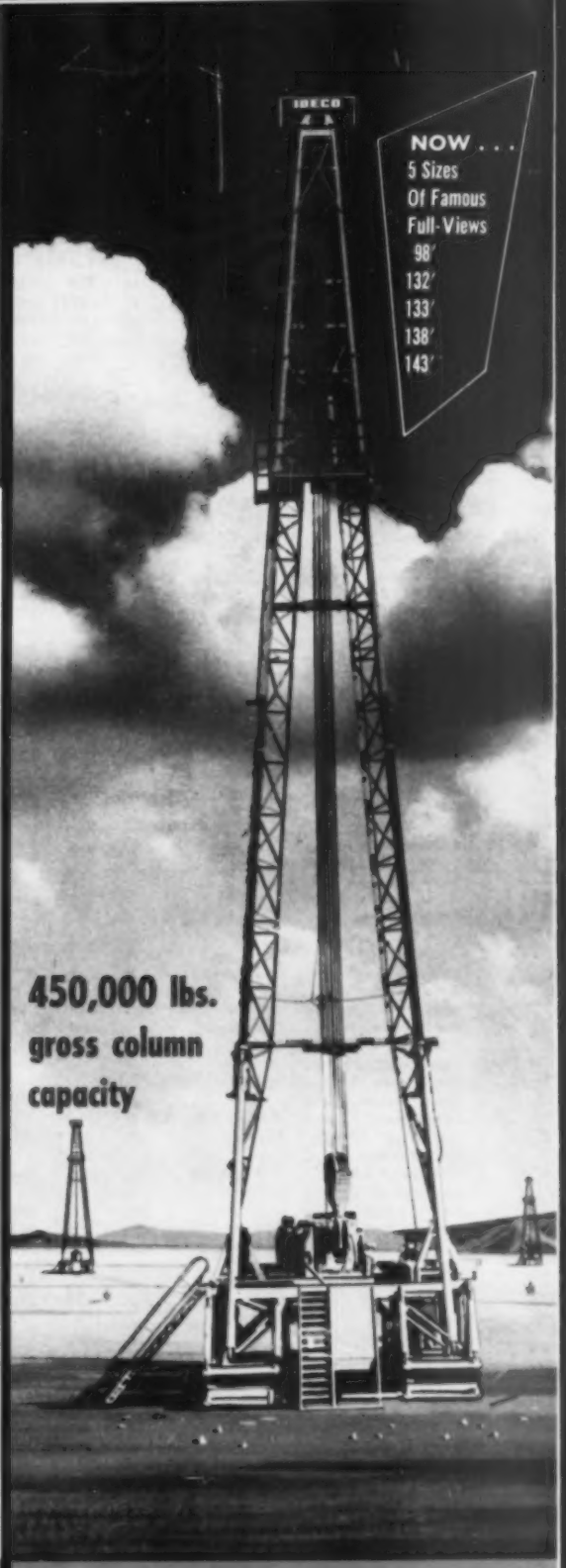
The entire structure is made up of road-size packages easily pin-connected. Portability is outstanding.

Easily change 98-foot mast to 132-foot or vice-versa

Merely by adding one section and reversing pedestals and base shoes a doubles mast becomes a trebles mast.



TIME-PROVED RAISING SYSTEM EMPLOYS RAISING LEGS WHICH LOCK IN POSITION AND BECOME STRUCTURAL MEMBERS OF MAST.



IDECO

P. O. BOX 1331 • DALLAS 21, TEXAS

When only the best will do . . . Use IDECO

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
C W Strotman Drlg Co	1	gas	145	3600	4500	Crdwll H
Edwards County						
Houchins Drlg Co	2	gaso	150	5000	—	Frnks Spdr
Fayette County						
Cummins Drlg Co	C-1	gas-gaso	65	1500	2000	B Erie 24-L
	C-2	gas-gaso	65	1500	2000	B Erie 24-L
	C-3	gas-gaso	65	1500	2000	B Erie 60-L
	C-4	gas-gaso	65	1500	2000	B Erie 60-L
	C-5	gas-gaso	78	2500	3500	B Erie 28-L
Gallatin County						
V S & S Drlg Co	3	gas	—	3500	3500	Cooper
Hamilton County						
C E Brehn	4	btne	184	—	5000	Crdwll K
Lawrence County						
Payne Bros Drlg Co	3	dsl	150	3000	4000	B Erie 36-L
Richland County						
Don Slape Drlg Co	1	btne	—	—	—	Crdwll K
Saline County						
C E Brehn	8	btne	184	—	5000	Crdwll K
C W Strotman Drlg Co	3	gas	130	3000	3500	Crdwll K
Wabash County						
Payne Bros Drlg Co	2	dsl	150	3000	4000	B Erie 36-L
Princeton Mining Co	1	gas	85	—	3500	Crdwll L
Washington County						
Graham Powell	1	btne	500	4200	4200	B Erie 36-L
INDIANA						
Gibson County						
Highland Oil	1	dsl	—	2000	—	B Erie 24-L
	2	dsl	—	3000	—	B Erie 28-L
C W Strotman Drlg Co	4	gas	175	3500	4000	B Erie 36-L
Martin County						
Payne Bros Drlg Co	1	dsl	150	3000	4000	B Erie 36-L
KANSAS						
Anderson County						
R L Horn & Sons Drlg Co	1	dsl	60	1600	2000	Star 72
Barber County						
Graham-Michaelis Drlg Co	3	dsl	150	3500	6000	B Erie 36
Patton Drlg Co Inc	3	gas	—	—	—	Crdwll
Butler County						
Strait Drlg Co	1	gas	175	3500	4000	B Erie 36-L
J H Wagner Drlg Co	3	gas-LPG	145	3500	4500	B Erie 36-L
Cowley County						
Butler County Drlg Co	1	dsl	130	3500	5000	Natl 3A-6
Paul Septer Drlg Co	7	btne	—	4500	—	B Erie 36-L
Ellis County						
Signal Oilfield Serv	9	dsl	150	—	6000	Crdwll RL
Finney County						
Graham-Michaelis Drlg Co	1	dsl	175	3000	8000	Crdwll
Labette County						
Veeder Supply & Dev Co	BE 2	dsl	120	3500	4500	B Erie
Marion County						
J H Wagner Drlg Co	2	gas-LPG	145	3500	4500	B Erie 36-L
Meade County						
Dunnam & Wyant Drlg Co	1	LPG	145	—	8000	Crdwll RL
Graham-Michaelis Drlg Co	2	dsl	175	3000	8000	Crdwll
	4	dsl	175	—	4000	Crdwll KL
Pratt County						
Signal Oilfield Serv	1	dsl	200	—	6000	Crdwll RL
	6	dsl	200	—	6000	Crdwll RL
Russell County						
Shields Oil Producers	2	gas	145	3500	3500	B Erie 48-L
Signal Oilfield Serv	3	gas	145	—	6000	Crdwll RL
KENTUCKY						
Christian County						
Marhill Oil & Gas Co Inc	1	gas-btne	145	6000	6000	B Erie 36
Hopkins County						
Riley & Gammon	1	dsl	60	1200	1800	B Erie 22
	2	gaso	30	600	1000	B Erie 20
Muhlenberg County						
Jack & H P Read	2	prop	78	3500	—	B Erie 28-L
	3	gaso	65	2000	—	B Erie 60-L
MICHIGAN						
Allegan County						
Muskegon Development Co	—	dsl	150	5000	5000	Natl
Bay County						
Muskegon Development Co	—	dsl	150	5000	5000	Natl
Branch County						
McClure Oil Co	3	gas	145	5000	5000	B Erie 36-L
Gladwin County						
Muskegon Development Co	—	dsl	150	5000	5000	Natl
Gratiot County						
McClure Oil Co	4	gas	145	4500	4500	B Erie 36-L
Montcalm County						
McClure Oil Co	1	gas	145	5000	5000	B Erie 36-L
	2	gas	145	5000	5000	B Erie 36-L
	5	gas	145	4500	4500	B Erie 36-L
Oceana County						
Lowell Bernhardt	1	gas-btne	78	3000	—	B Erie 28
Ogemaw County						
Muskegon Development Co	—	dsl	150	5000	5000	Natl
Osceola County						
Gordon Drlg Co	5	gas-LPG	150	4000	5000	Crdwll H
Saginaw County						
Muskegon Development Co	—	LPG	165	6000	6000	Wlkr-Nr S-33
MONTANA						
Blaine County						
M-H-O Drlg Co	6	dsl	140	3000	4500	B Erie 36-L
Fallon County						
Signal Oilfield Serv	10	dsl	225	—	12,000	Frnks Clpr
Glacier County						
M-H-O Drlg Co	4	gas-btne	165	3500	5000	B Erie 36-L
	7	dsl	220	6000	8000	B Erie 48-L
Liberty County						
B & B Drlg Co (Montana)	1	gas	145	3500	—	B Erie 36-L
Pondera County						
J W Lawrence	1	gas-gaso	125	3500	—	Natl
	2	gas-gaso	175	5000	—	B Erie
Treasure State Drlg Co	1	gas	140	3500	4500	B Erie 36-L
NEBRASKA						
Dawson County						
Nemaha Oil Co	1(wo)	gas	150	—	4500	Wichtex C-60
Kimble County						
Signal Oilfield Serv	4	dsl	200	—	8000	Crdwll RL
	11	dsl	—	—	8000	Crdwll RL
NEVADA						
Churchill County						
Barry Well Drlg	3	gas	85	—	500	Custom
NEW MEXICO						
Chaves County						
Keyes Drlg Co	4	LPG	53	1500	2500	B Erie 24-L
Eddy County						
Aldridge & Stroud Inc	8	LPG	145	4500	4500	Wichita 61
Kersey & Company	1	gas-gaso	185	5000	5000	Natl 3
	2	gas-gaso	120	3000	3500	Wich Spdr 55
	3	gas-gaso	120	4000	4500	Wich Spdr 61
	4	gas-gaso	120	4000	4500	Natl 3
Needham Drlg Co	1	dsl	160	5000	—	Wich Spdr 66
	2	LPG	180	5000	—	Wich Spdr 66
S P Yates Drlg Co	3	LPG	150	3500	—	Wichita 55
	4	LPG	130	3000	—	Ft Wrth Spr J
	5	LPG	180	6000	—	Ft Wrth Jumbo J
	6	LPG	180	6000	—	Ft Wrth Jumbo J
Lea County						
Art West Drlg Co	4	gas	145	—	8000	Crdwll RL
San Juan County						
Signal Oilfield Serv	13	dsl	—	—	8000	Crdwll RL
Union County						
Clayton-Dwyer Drlg Co	1	dsl	600	10,000	3½ " 10,000	Unit U-15
OHIO						
Hancock County						
H J Lininger	2	dsl	175	3500	—	L C Moore
Hocking County						
R A Cooper Drlg Co	1	gas	—	4000	4000	Natl 12
Wyandot County						
H J Lininger	1	gas-gaso	78	2500	—	Beth Cyclone
	3	gas-gaso	65	1800	—	Beth Cyclone
OKLAHOMA						
Beaver County						
Chambless-Rosen Drlg Co	2	gas	145	—	10,000	Crdwll
Beckham County						
G H Ray Well Service Co	6	gaso-gas	—	12,000	—	Crdwll S-60
Caddo County						
G H Ray Well Service Co	1	gaso-gas	—	12,000	—	Wlsn Master
	5	gaso-gas	—	12,000	—	Crdwll RL
	7	gaso-gas	—	14,500	—	Wilson
	8	gaso-gas	—	12,000	—	Crdwll
Comanche County						
Thompson Drlg Co	1	LPG	150	1500	2000	Extess

Hi! since you are looking through this magazine, chances are you're going to drill a well...

...and

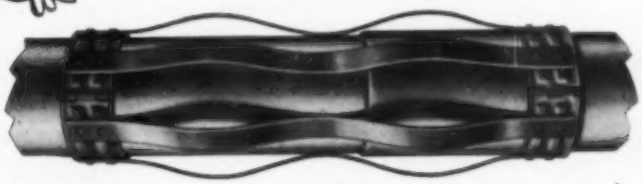
if you do, you are going to need dependable floating equipment...

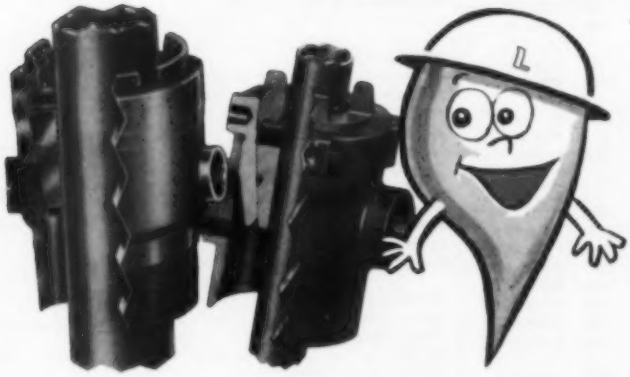
MAKE IT LARKIN.

...also

you'll need casing centralizers to help make sure of a good cement job.

MAKE IT LARKIN.





...and

if you are going to drill in an area of medium depths and pressure, you'll need a compact, dependable and economical casing head and tubing head.

MAKE IT LARKIN.

All Larkin Products are available "through your supply store"

LARKIN PACKER COMPANY, INC.
WAXAHACHIE, TEXAS

LARKIN
...Through Your Supply Store

LARKIN LEADERSHIP HAS BEEN EARNED BY YEARS OF DEPENDABLE PERFORMANCE

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top of Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
Creek County						
Bennett Drlg Co	3	LPG	—	2750	3250	B Erie 28-L
E & M Drlg Co	2	gas	140	3000	4500	Wlk-Nr 32 S
4-J Drlg & Well Serv Co	1	gaso	—	—	4500	B Erie 36-L
	2	gaso	—	—	3500	Wlkr-Nr
C H Hartman	1	—	—	3500	—	—
Muzny Drlg Co	1	gas-gaso	145	4500	6000	Ft Wrth D
O C Tut Tilley Co	2	LPG-gas	140	3000	4500	B Erie 36-L
Garfield County						
Chambless-Rosen Drlg Co	3	gas	145	—	10,000	Crdwll
Hayward Drlg Co	2	gas	—	4000	—	Brwstr
Grant County						
Sooner Drlg Co	2	LPG	145	5000	7500	Wlkr-Nr
Kay County						
Dave Morgan Drlg Co	—	LPG-gas	145	—	6500	Crdwll RL
Lincoln County						
Muzny Drlg Co	2	gas-gaso	65	1200	1600	Ft Wrth U
Logan County						
Bodard Drlg Co	2	gas	225	7000	7000	Wlkr-Nr C-34
Sooner Drlg Co	4	LPG	145	5000	7500	Wlkr-Nr
Muskogee County						
Ralph G Ladd	1	gas-gaso	65	1750	2500	Star Spdr K
Noble County						
Chambless-Rosen Drlg Co	4	gas	145	—	10,000	Crdwll
Nowata County						
Bennett Drlg Co	6	LPG	—	1750	2250	B Erie 24-L
Okfuskee County						
Floyd R Hyer	1	gas-gaso-btne	60	2250	2750	Star K Spdr
Skinner & McDougal Drlg Co	1	gaso-btne	145	4000	6500	Crdwll
	2	gaso-btne	145	4000	5500	Wlkr-Nr
Okmulgee County						
Bennett Drlg Co	5	LPG	—	2750	3250	B Erie 28-L
Gold-Mar Drlg Co	1	LPG	125	2500	3500	Wich Spdr 25
Osage County						
Bennett Drlg Co	9	LPG	—	3500	4500	Wlkr-Nr 34
W C Holt Drlg Co Inc	1	gas	130	3000	4000	Wlkr-Nr
Signal Oilfield Serv	7	gas	145	—	5000	Wlkr-Nr C-34
	8	gas	145	—	5000	Wlkr-Nr C-34
Tolson Drlg Co	1	LPG	145	4000	5000	Wlkr-Nr S-33
Payne County						
Foster Drlg Co	1	prop	135	—	3500	Cooper
Skinner & McDougal Drlg Co	3	gaso-btne	145	4000	5500	Crdwll
Pontotoc County						
Joe Lawrence Drlg Co	1	gas	160	3500	3800	Crdwll H
Pottawatomie County						
Sooner Drlg Co	6	gas-LPG	145	—	6500	Crdwll RL
O C Tut Tilley Co	3	LPG-gas	145	3000	4500	B Erie 36-L
Seminole County						
O C Tut Tilley Co	1	LPG-gas	185	—	8000	Crdwll RL
Troup & Suttles Inc	1	gas-gaso	145	—	9000	Wlkr-Nr 33
Tulsa County						
Bar-Lee Drlg Co	1	LPG	120	3000	3500	Wlkr-Nr 32
J M C Drlg Interests	2	gas	—	1500	—	Keystone
J M Corbett	1	gas	—	5000	6500	Ft Wrth
Tyco Drlg Corp	1	gas	138	—	—	B Erie 36-L
Wagoner County						
Rud Drlg Co	—	btne	120	2500	3500	B Erie 28-L
	—	btne	90	1500	2000	B Erie 60-L
	—	btne	90	1500	2000	B Erie 60-L
	—	btne	110	2000	3000	Wlkr-Nr
	—	btne	120	2500	3500	B Erie 28-L
	—	btne	130	2500	3500	B Erie 28-L
	—	btne	90	1500	2500	Keystone
	—	btne	130	2500	350	B Erie 28-L
Washington County						
Bennett Drlg Co	8	LPG	—	2750	3250	B Erie 28-L
	10	LPG	—	2000	2500	B Erie 60-L
K & S Drlg Co	1	LPG	—	2500	—	B Erie 28-L
	2	LPG	—	2500	—	B Erie
PENNSYLVANIA						
Berks County						
C S Garber & Sons Inc	32	gas-gaso	32	1500	—	—
	33	gas-gaso	32	1500	—	—
	34	gas-gaso	32	1500	—	—
Clearfield County						
Fairman Drlg Co	1	dsl	225	7500	8000	B Erie Spdr 48-L
Indiana County						
Fairman Drlg Co	3	gas	225	7500	8000	B Erie Spdr 48-L
	5	dsl	170	5000	6000	B Erie Spdr 36-L
Jefferson County						
Fairman Drlg Co	4	gas	225	7500	8000	B Erie Spdr 48-L
Montgomery County						
C S Garber & Sons Inc	29	gas-gaso	32	1500	—	—
	30	gas-gaso	32	1500	—	—
	31	gas-gaso	32	1500	—	—
Potter County						
Fairman Drlg Co	2	dsl	225	7500	8000	B Erie Spdr 48-L
TEXAS						
Archer County						
Bolin Oil Co & D H Bolin	8	gas	145	4500	—	Wlkr-Nr S-45
Callahan County						
Jones Well Serv Co	2	gas-gaso	175	3500	6000	B Erie 36-L
Cochran County						
Western Drlg Co Inc	10	btne	185	—	—	B Erie 48-L
Coleman County						
W H McGarr Ind	1	gas-LPG	120	4500	4500	Wich 61
	2	gas-LPG	100	2500	2500	Ft Wrth Spr D
Oney Drlg Co	3	gas	210	6500	—	Wichita
Colorado County						
Western Drlg Co Inc	7	dsl	185	—	—	B Erie 48-L
Comanche County						
Choate & Hitt	1	LPG	160	4000	5000	Ft Wrth S J
Cooke County						
Russell & Russell Drlg & Prod Co	1	gaso	80	2500	2500	Ft Wrth Spr H
Crane County						
Aldridge & Stroud Inc	9	LPG	—	6000	6000	Ft Wrth J
	11	LPG	145	6000	6000	Wichita 61
McQueen & Stout Drlg Co	20	LPG	185	5000	5000	Crdwll RL
Crockett County						
Aldridge & Stroud Inc	4	LPG	—	2500	2500	Fr Wrth D
Eastland County						
Kent & Preston	2	btne	120	4000	4000	Ft Wrth Jumbo
Ector County						
Aldridge & Stroud Inc	2	LPG	525	2500	5000	B Erie 36-L
	5	LPG	—	3000	3000	B Erie 28-L
McQueen & Stout Drlg Co	16	LPG	185	5000	5000	Crdwll RL
	18	LPG	145	5000	—	Natl 3
Art West Drlg Co	1	gas	185	—	8000	Crdwll RL
	6	gas	185	—	9000	Wisn Giant
	7	dsl	125	—	8000	Crdwll RL
Gaines County						
Western Drlg Co Inc	5	btne	185	—	—	B Erie 48-L
Gray County						
C F Hills Drlg Co	3	gas-btne	145	6000	7800	Wlkr-Nr C-34
Holt Bros Drlg Co	1	gas-btne	—	4000	—	B Erie 36-L
I J Huval Well Serv Co	1	gas-gaso-LPG	145	4000	10,000	Wisn Mogul Spdr
	2	gas-gaso-LPG	145	4000	10,000	Wisn Mogul Spdr
Hockley County						
Western Drlg Co Inc	4	btne	185	—	—	B Erie 48-L
	8	btne	185	—	—	B Erie 48-L
Hutchinson County						
C F Hills Drlg Co	2	gas-btne	145	5000	9000	Wlkr-Nr S-33
J R McGill	1	gas-gaso	—	—	—	B Erie
	2	gas-gaso	—	—	—	B Erie
Jack County						
Ramey Well Service	1	LPG	140	—	8000	Wichtex E-75
Jones County						
Oxford & Stasney Drlg Co	3	dsl	265	5000	7500	Brwstr N-4
Knox County						
Jones Well Serv Co	1	gas-gaso	175	3500	6000	B Erie 36-L
Lubbock County						
Western Drlg Co Inc	2	btne	145	—	—	B Erie 36-L
	3	btne	145	—	—	B Erie 36-L
McCulloch County						
Kent & Preston	1	dsl	160	6000	—	Ft Wrth J-37
Mitchell County						
Ellis Drlg Corp	2	btne	45	2400	3000	B Erie 28-L
Willard Gladson & Odstrcil Bros Drlg Co	1	btne	—	—	—	B Erie 28-L
	2	btne	—	—	—	B Erie 36-L
Hissom Drlg Co	5	gas	180	7500	10,000	Crdwll RL
Nolan County						
Jones Well Serv Co	3	gas-gaso	175	3500	6000	B Erie 36-L
Oxford & Stasney Drlg Co	1	dsl	530	7500	10,000	Wisn Giant
Pecos County						
Brown & Thorp Drlg Co	2	LPG	135	5500	—	Wichita 66
	5	LPG	135	4000	—	Ft Wrth D
Reagan County						
Wilbanks & Rutter Drlg Co	2	gas	—	—	—	—
Scurry County						
Ellis Drlg Corp	1	btne	45	2400	3000	B Erie 28-L
Willard Gladson & Odstrcil Bros Drlg Co	3	btne	—	—	—	B Erie 36-L
Shackelford County						
J Conley Miles Drlg Co	1	btne	80	1750	2500	B Erie 24-L
	1	btne	114	2500	3500	Ft Wrth D

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
W H Varner Drlg Co	1	gaso	75	1500	—	B Erie 22-W
	1	btne	150	—	—	Wisn Spr
Stephens County						
Choate & Hitt	1	LPG	185	5000	6500	Ft Wrth J J
E & H Drlg Co	1	gas-btne	550	7500	10,000	Unit U-15
Sutton County						
Saunders Drlg Inc	1	LPG	70	2500	3000	B Erie 28-L
Taylor County						
West Central Drlg Co	2	gas-gaso	180	3000	6000	Ft Wrth J
Throckmorton County						
Cannon Drlg Co	2	dsl	225	4000	7000	Natl T-12
Ellis Drlg Corp	3	btne	60	4000	5000	B Erie 36-L
Jack L Story	S-1	dsl	100	8000	9000	Wlkr-Nr C-37
Upton County						
Brown & Thorp Drlg Co	3	LPG	180	4000	—	Ft Wrth F-37
	4	LPG	135	4000	—	Ft Wrth F
	6	LPG	180	4000	—	Ft Wrth F
	7	LPG	135	4500	—	Wichita 61
	8	LPG	135	3500	—	Ft Wrth D
	9	LPG	135	3500	—	Ft Wrth D
	10	LPG	135	3500	—	Wichita 55
	11	LPG	135	3500	—	Ft Wrth D
Buck Jones Drlg Co	1	btne	140	4000	4000	Wlkr-Nr 33
	2	btne	100	2500	2500	Wlkr-Nr 32
	3	btne	150	5000	5000	Natl 3
Ward County						
Aldridge & Stroud Inc	7	LPG	145	—	8500	Crdwll RL
Eastland Oil Co	6	gas	125	4500	6000	B Erie
J E B Drlg Co	1	gas-gaso-btne	145	5000	6500	Wlkr-Nr S-33
Art West Drlg Co	2	gas	145	—	8000	Crdwll RL
Wichita County						
Lin-Mour Drlg Co	2	gas	125	—	6500	Wlkr-Nr C-34
Wilbarger County						
Dublin-Kiel	2	LPG	140	2000	3000	Wlkr-Nr S-32
Williamson County						
H J Steward	1	gaso	60	—	2000	Ft Wrth D
Winkler County						
R L Bob Clark Drlg Contr	2	LPG	90	3500	4500	B Erie
	3	LPG	130	3500	4500	B Erie
Donnell Drlg Co	1	gas-btne	—	5000	5000	Wichita 61
	2	gas-btne	—	5000	5000	Wichita 61
	3	gas-btne	—	5000	5000	Wichita 55
Art West Drlg Co	3	gas	145	—	8000	Crdwll RL
	5	gas	145	—	6000	Crdwll KL
Young County						
E & H Drlg Co	2	gas-btne	225	4500	6000	Unit U-34
Oney Drlg Co	1	gas	165	5500	—	Wichita
	2	gas	145	5500	—	Wichita
	4	gas	145	5500	—	Ft Wrth
Ramey Well Service	2	LPG	140	—	8000	Wichtex E-75
UTAH						
Uintah County						
Charles M Jameson	1	gas-gaso	—	—	—	B Erie 36-L
WEST VIRGINIA						
Logan County						
Allen Drlg Co	3	gas	128	5000	6000	B Erie Spdr 36-L
	4	gas	128	5000	6000	B Erie Spdr 36-I
Mingo County						
Allen Drlg Co	1	gas	128	5000	6000	B Erie Spdr 36-L
	2	gas	145	5000	6000	B Erie Spdr 36-L
	5	gas	145	5000	6000	B Erie Spdr 36-L
Raleigh County						
Allen Drlg Co	7	gas	175	3500	5000	Natl Mach 2
WYOMING						
Big Horn County						
Morrison Drlg Co Inc (Wyo)	3	btne	185	5500	8000	Crdwll
Johnson County						
Prairie Drlg Co		gas	—	—	—	Crdwll RL
Natrona County						
Morrison Drlg Co Inc (Wyo)	1	btne	145	4500	6000	Crdwll
	2	btne	185	5500	8000	Crdwll
Sweetwater County						
Morrison Drlg Co Inc (Wyo)	4	btne	185	5500	8000	Crdwll

CANADIAN DRILLING CONTRACTORS

ROTARY AND CABLE TOOLS

ALPHABETICAL LISTING

Able Drlg Co
Three Hills, Alberta, Canada

Anderberg & Sons Drlg Ltd
8 Hatfield Ct
Calgary, Alberta, Canada

Arrow Drlg Co
201 Oil Exchange Bldg
Calgary, Alberta, Canada

Peter Bawden Drlg Ltd
810-A First St W
Calgary, Alberta, Canada

Bennett & Hurst Drlg Co Ltd
1315 First St W
Calgary, Alberta, Canada

Big Horn Drlg Ltd
6530 100th St
Edmonton, Alberta, Canada

Brinkerhoff Drlg Co Ltd
1001 Mobil Oil Bldg
Calgary, Alberta, Canada

Brown Drlg Ltd
10509 81st Ave
Edmonton, Alberta, Canada

Can American Drlg Ltd
133 Sixth Ave E
Calgary, Alberta, Canada

Can-Tex Drlg Co Ltd
239 Sixth Ave W
Calgary, Alberta, Canada

Cascade Drlg Co Ltd
330 Ninth Ave W
Calgary, Alberta, Canada

Central Leduc Drlg Co Ltd
224 Ninth Ave W
Calgary, Alberta, Canada

Commonwealth Drlg Co Ltd
122 Eighth Ave W
Calgary, Alberta, Canada

Coralta Drlg Ltd
Box 4104
Edmonton, Alberta, Canada

Coultis Drlg Ltd
1724 Suffolk St
Calgary, Alberta, Canada

Dallas Drlg Co Ltd
1208 First Natl Bk Bldg
Dallas Tex

Devon Drlg Co Ltd
703 Fifth St W
Calgary, Alberta, Canada

Dominion Drlg Co Ltd
401 Petroleum Bldg
Edmonton, Alberta, Canada

Double "A" Drlg Co Ltd
709 Eighth Ave W
Calgary, Alberta, Canada

Duke Drlg Co Ltd
121 Eighth Ave W
Calgary, Alberta, Canada

Eakle & Holder Drlg Co
116 Mulberry St
Evansville Ind

General Petroleums of Canada Ltd
224 Ninth Ave W
Calgary, Alberta, Canada

Gustavson Drlg Co Ltd
208 Alberta Block
Calgary, Alberta, Canada

Hi-Tower Drlg Co Ltd
400 Lancaster Bldg
Calgary, Alberta, Canada

Hunter Drlg Ltd
602 Seventh Ave W
Calgary, Alberta, Canada

Kenyon's Drlg Serv Co Ltd
10439 82nd Ave
Edmonton, Alberta, Canada

Loffland Bros Co
Box 1649
Tulsa, Okla

Lohmann-Johnson Drlg Co Ltd
208 Bamlett Bldg
Calgary, Alberta, Canada

Moore Drlg Co Ltd
6th Floor Petroleum Bldg
Calgary, Alberta, Canada

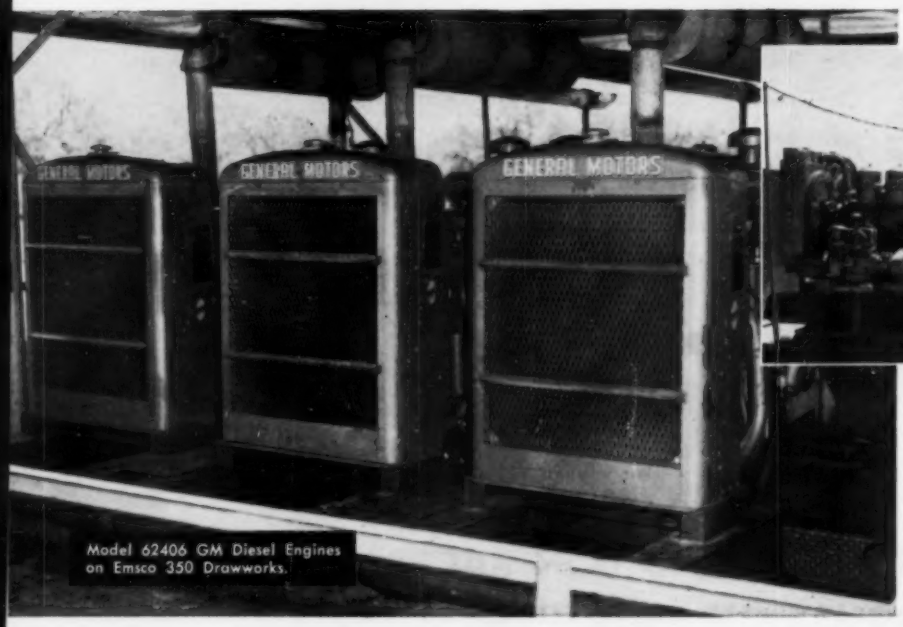
Mortenson Drlg Co
8706 83rd Ave
Edmonton, Alberta, Canada

Parker Drlg Co of Canada Ltd
409 Eighth Ave W
Calgary, Alberta, Canada

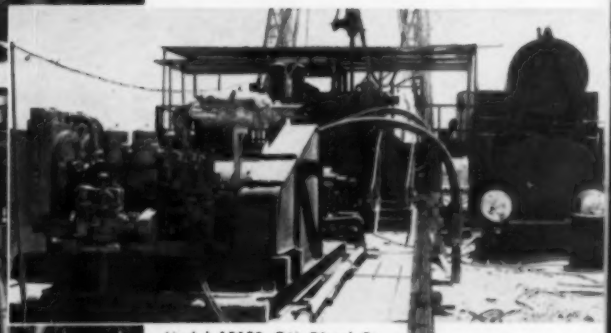
Pennant Drlg Ltd
108-A Eighth Ave W
Calgary, Alberta, Canada

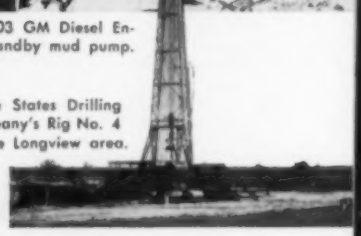
Precision Drlg Co Ltd
1134 Eighth Ave W
Calgary, Alberta, Canada

DEPENDABLE POWER



Model 62406 GM Diesel Engines on Emsco 350 Drawworks.


Model 12103 GM Diesel Engine on Standby mud pump.


South States Drilling Company's Rig No. 4 in the Longview area.

STORY OF A "REVITALIZED" RIG

When South States Drilling Company, Longview, Texas, decided to repower their Rig No. 4, they chose Stewart & Stevenson GM Diesel Power through Industrial Power & Supply. Gas/butane powered engines formerly were used.

The results?

"We noticed a decided improvement in power and acceleration," Mr. B. J. Baird testifies, "particularly in coming off bottom with a heavy string of drill pipe. We were able to reduce our trip time considerably."

Rig No. 4 has an Emsco GA 350 Drawworks with a 7¼-inch by 14-inch Gardner-Denver mud pump. This was repowered with three 6-110 GM Diesel Engines. Also, Rig No. 4 has a B-14 Emsco mud pump for stand-by service powered by a Model 12103 GM Diesel Engine.

This drilling contractor found the pump on the compound could be used to its rated capacity after the repowering job. This is without loss of drilling power on the rotary table.

Economy: "A 40% savings over our past operation," Mr. Baird says.

Overall performance: "Well pleased."

Service: "Excellent."

Stewart & Stevenson Services, Inc., the world's largest distributor of diesel engines, has the answer to your drilling power needs, regardless of the size or type of your rig.

A combination of the right power and utmost efficiency in service means more efficient operations for you. And that's money in the bank.

STEWART & STEVENSON

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Main Office and Plant:	4516 Harrisburg Blvd., Houston 11, Texas Phone CApitol 5-5341
Branches:	Corpus Christi, Dallas, Lubbock, San Juan, Odessa
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We're proud of our record in meeting every power need for the nation's leading drilling contractors

THE WORLD'S LARGEST DISTRIBUTOR OF DIESEL ENGINES

Reading & Bates Drlg Co Ltd
Royal Bk Bldg
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Regent Drlg Co Ltd
Box 421
Edmonton, Alberta, Canada

Stewart Drlg Co Ltd
10856 82nd Ave
Edmonton, Alberta, Canada

Thornton & Bates Drlg Co
Royal Bk Bldg
Calgary, Alberta, Canada

Trident Drlg Co Ltd
830 Eighth St W
Calgary, Alberta, Canada

Trinity Canadian Drlg Co
1001 F R Webster Bldg
237 Seventh Ave W
Calgary, Alberta, Canada

Tri-Province Drlg Co Ltd
307 Sixth Ave W
Calgary, Alberta, Canada

Union Rotary Drlrs (Canada) Ltd
155 Wellington St
Sarnia, Ontario, Canada

Wilrich Petroleums Ltd
10584 107th St
Edmonton, Alberta, Canada

Canadian Contract ROTARY Drilling Rigs

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ALBERTA PROVINCE						
Arrow Drlg Co	6	dsl	250	Emsco GB-350	350	7,000
	7	dsl	600	Emsco GC-500	700	9,000
	8	dsl	250	Emsco GB-350	350	7,000
	19	dsl	250	Emsco GB-350	350	7,000
	21	dsl	600	Emsco J-1250	1400	14 000
Can-Tex Drlg Co Ltd	—	—	—	Emsco GB-800	—	12,000
	—	—	—	Emsco J-1100	—	15,000
	—	—	—	Emsco GA-500	—	8,000
	—	—	—	"Oilwell" 64B	—	7,500
	—	—	—	Natl T-25	—	5,500
	—	—	—	Crdwll OT	—	7,000
	—	—	—	"Oilwell" 66	—	8,000
	—	—	—	Crdwll OC	—	8,000
	—	—	—	Emsco GB-800	—	12,000
Lufftand Bros Co	C-1	dsl	740	—	900	11,000
	C-2	dsl	600	—	600	9,000
	C-3	dsl	970	—	1275	14,000
	C-4	dsl	1000	—	1275	15,000
	C-5	dsl	1570	—	1275	14,000
	C-6	dsl	1200	—	1200	16,000
Airdrie						
Commonwealth Drlg Co Ltd	23	dsl	865	Emsco GC-500	800	8,500
Barons						
Brinkerhoff Drlg Co Ltd	2	dsl	370	Natl 50-A	600	8,000
Bellshill Lake						
Big Horn Drlg Ltd	1	dsl	300	Crdwll S-350	250	5,000
Regent Drlg Co Ltd	2	dsl	520	Brwstr N-7	520	8,000
Bentley						
Commonwealth Drlg Co Ltd	27	dsl	870	Natl 50-A	660	8,000
Bohn Lake						
Wilrich Drlg Ltd	4	dsl	110	Failing 2500	110	3,000/3½"
Bragg Creek						
General Pet of Canada Ltd	18	ds	1400	Natl 80-B	1150	10,000
Buck Lake						
Able Drlg Co	20	gas	46	Mayhew	—	1,000/2⅛"
Calgary						
Anderberg & Sons Drlg Ltd	1	gaso	—	Mayhew 1000	—	1,000/2⅛"
Duke Drlg Co Ltd	5	dsl	700	Unit U-20	1386	13,500
Parker Drlg Co of Canada Ltd	12	dsl	600	"Oilwell" 66	670	9,000
Calgary (North)						
Duke Drlg Co Ltd	8	dsl	500	Unit U-40	670	10,000
Carbon						
Hi-Tower Drlg Co Ltd	9	dsl	285	Crdwll D	300	5,000
Cardston						
Brinkerhoff Drlg Co Ltd	22	dsl	900	Natl 110	1450	15,000
General Pet of Canada Ltd	17	dsl	1400	Natl 55	1050	7,000
Carstairs						
Stewart Drlg Co Ltd	1	dsl	—	Unit U-15	—	7,500
Drayton Valley						
Commonwealth Drlg Co Ltd	3	dsl	690	Natl 50	600	6,500
	10	dsl	440	Crdwll O	480	6,000
Dominion Drlg Co Ltd	3	dsl	600	Natl T-32	320	5,000
	2	dsl	580	Natl 50-A	450	6,500
Duke Drlg Co Ltd	2	dsl	650	Natl 50	650	8,000
Gustavson Drlg Co Ltd	1	dsl	500	Natl 50	500	7,500
Hi-Tower Drlg Co Ltd	4	dsl	350	Natl 50	450	6,500
	5	dsl	350	Natl 50	450	5,000
	7	dsl	525	"Oilwell" 66	550	8,000
	8	dsl	570	Unit U-15	600	8,000
Moore Drlg Co Ltd	2	dsl	600	Emsco 450	640	7,500
East Tangent						
Gustavson Drlg Co Ltd	5	dsl	420	Natl T-32	275	6,500
Eckville						
Regent Drlg Co Ltd	6	dsl	750	Brwstr N-75	780	10,000
Edmonton						
Peter Bawden Drlg Ltd	5	dsl	440	Natl T-32	270	5,500
Coralta Drlg Ltd	—	gas	180	Failing 1500	180	1,500/2⅛"
Kenyon's Drlg & Serv Ltd	11	dsl	—	Crdwll 151	—	5,000/3½"
Moore Drlg Co Ltd	5	dsl	380	Crdwll EC	380	6,000
	6	dsl	40-	Emsco 300	300	6,000
Mortenson Drlg Co	2	gaso	5 x 6	Failing CFD1	110	1,000
Wilrich Drlg Ltd	6	dsl	300	Unit U-34	300	6,000
Edson						
Regent Drlg Co Ltd	25	dsl	750	Brwstr N-75	780	10,000
Trident Drlg Co Ltd	8	dsl	—	"Oilwell" 96	1920	15,000
	13	dsl	—	"Oilwell" 66	640	7,000
Eureka River						
Regent Drlg Co Ltd	9	dsl	750	Brwstr N-75	780	10,000
Fort MacLeod						
Duke Drlg Co Ltd	6	dsl	850	Unit U-20	1386	13,500
Fort Saskatchewan						
Wilrich Drlg Ltd	2	dsl	120	Natl T-12	160	3,500/3½"
Grande Prairie						
Parker Drlg Co of Canada Ltd	1	dsl	615	"Oilwell" 76	750	10,000
	2	dsl	615	"Oilwell" 76	750	10,000
	3	dsl	765	"Oilwell" 76	1005	11,000
Regent Drlg Co Ltd	26	dsl	260	Ideco H-40	260	6,000
Trident Drlg Co Ltd	10	dsl	—	Emsco GB-350	510	6,500
Harmatton						
Commonwealth Drlg Co Ltd	28	dsl	920	Natl 55	1000	10,000
Trident Drlg Co Ltd	9	dsl	—	"Oilwell" 76	960	10,000
High Prairie						
General Pet of Canada Ltd	5	dsl	800	Natl 75	1000	10,000
High River						
Commonwealth Drlg Co Ltd	21	dsl	1250	Ideco 7-11	900	10,500
Pennant Drlg Ltd	2	dsl	1155	Brwstr N-7	755	8,500
Trident Drlg Co Ltd	4	dsl	—	Natl 100	1200	13,000
Innisfail						
Hi-Tower Drlg Co Ltd	1	dsl	525	"Oilwell" 66	550	8,000
Joffre						
Brown Drlg Ltd	1	dsl	275	Crdwll S	—	5,000
Keystone						
Peter Bawden Drlg Ltd	1	dsl	415	Natl T-32	275	5,500
General Pet of Canada Ltd	6	dsl	400	Natl 50-A	500	7,000
Parker Drlg Co of Canada Ltd	4	dsl	400	Natl 50	500	6,500
Ladgepole						
Commonwealth Drlg Co Ltd	17	dsl	400	Emsco GB-350	465	6,000
Makepeace						
Gustavson Drlg Co Ltd	3	dsl	275	Ideco H-40	300	6,000
Medicine						
Gustavson Drlg Co Ltd	4	dsl	850	Natl 55	850	10,000
Nanton						
Brinkerhoff Drlg Co Ltd	8	dsl	900	Natl 110	1300	15,000
Reading & Bates Drlg Co Ltd	8	dsl	1500	Natl 110	1950	18,000
Nordegg						
General Pet of Canada Ltd	7	dsl	1400	Natl 80-B	1300	13,000
Normandville						
Commonwealth Drlg Co Ltd	19	dsl	735	Natl 50-A	790	8,000
Peace River						
Dominion Drlg Co Ltd	4	dsl	600	Emsco GB-250	300	5,000
Pembina						
Brinkerhoff Drlg Co Ltd	16	dsl	370	Emsco GA-350	450	7,500
	20	dsl	370	Natl 50-A	450	8,500
Cascade Drlg Co Ltd	1	dsl	—	Natl 50	—	6,500
	3	dsl	—	Natl 50	—	6,500
	7	dsl	—	Natl 50-A	—	7,500
	8	dsl	—	Natl 50	—	6,500
	9	dsl	—	Natl T-32	—	5,500
	10	dsl	—	Natl 50	—	6,000
	15	dsl	—	"Oilwell" 64B	—	6,000

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Double-A Drlg Co Ltd	2	dsl	800	Ideco H-525	600	8,000
General Pet of Canada Ltd	3	dsl	425	Natl 50-A	650	7,000
	14	dsl	350	Crdwll OA	500	6,500
Reading & Bates Drlg Co Ltd	6	dsl	375	Natl 50	675	7,000
Regent Drlg Co Ltd	1	dsl	260	Brwstr N-4	260	6,000
	3	dsl	720	Brwstr N-55	520	8,000
Thornton & Bates Drlg Co	5	dsl	375	Natl 50-A	600	7,000
Trident Drlg Co Ltd	1	dsl	—	"Oilwell" 64B	640	5,000
	3	dsl	—	"Oilwell" 64B	640	5,000
	12	dsl	—	Unit U-15	640	7,500
Tri-Province Drlg Co Ltd	2	dsl	520	Beth Twstr S-55	520	7,500
	6	dsl	520	Ideco H-525	520	7,500
Pigeon Lake						
Trident Drlg Co Ltd	7	dsl	—	"Oilwell" 76	960	10,000
Pincher Creek						
Brinkerhoff Drlg Co Ltd	19	dsl	850	Emsco A-800	1269	14,000
	21	dsl	850	Emsco GB-800	1269	13,500
Commonwealth Drlg Co Ltd	1	dsl	1350	Natl 110	1500	14,000
General Pet of Canada Ltd	11	dsl	1400	Natl 80-B	1150	10,000
Ponoka						
Brinkerhoff Drlg Co Ltd	1	dsl	625	Emsco GC-500	846	10,000
Regent Drlg Co Ltd	28	dsl	500	Natl 50-A	520	7,000
Priddis						
Cascade Drlg Co Ltd	14	dsl	—	Unit U-20	—	14,000
Red Deer						
Peter Bawden Drlg Ltd	6	dsl	722	Unit U-36A	722	8,500
Rimbey						
Commonwealth Drlg Co Ltd	8	dsl	600	Brwstr N-7	600	8,000
General Pet of Canada Ltd	4	dsl	500	Natl 50-A	650	7,000
Hi-Tower Drlg Co Ltd	3	dsl	525	"Oilwell" 66	550	8,000
Moore Drlg Co Ltd	1	dsl	1000	Unit U-40	1000	10,000
Stettler						
Lohmann-Johnson Drlg Co Ltd	1	dsl	550	"Oilwell" 66	550	7,500
Parker Drlg Co of Canada Ltd	8	dsl	400	Natl 50	500	6,500
	11	dsl	400	Natl 50	500	6,500
Regent Drlg Co Ltd	30	dsl	260	Ideco H-40	260	6,000
Tri-Province Drlg Co Ltd	4	dsl	520	Emsco GA-350	520	6,000
Sturgeon Lake						
Peter Bawden Drlg Ltd	2	dsl	750	Natl 55	750	9,500
Commonwealth Drlg Co Ltd	9	dsl	1020	Ideco 700	940	10,000
Sundre						
Brinkerhoff Drlg Co Ltd	18	dsl	625	Emsco GC-500	846	10,000
General Pet of Canada Ltd	10	dsl	1400	Natl 80	1000	12,000
	15	dsl	1400	Natl 55	1050	10,000
	16	dsl	1050	Natl 55	1150	6,500
Hi-Tower Drlg Co Ltd	10	dsl	755	"Oilwell" 76	800	12,000
Parker Drlg Co of Canada Ltd	9	dsl	765	Natl 125	1005	12,000
Reading & Bates Drlg Co Ltd	3	dsl	950	Natl 75	1050	10,000
Regent Drlg Co Ltd	7	dsl	1200	Natl 125	1500	17,000
Tri-Province Drlg Co Ltd	1	dsl	1000	Unit U-40	850	11,000
Swan Hills						
Hi-Tower Drlg Co Ltd	6	dsl	755	"Oilwell" 76	800	12,000
Sylvan Lake						
Cascade Drlg Co Ltd	4	dsl	—	Natl 50-A	—	7,500
Three Hills						
Able Drlg Co	10	gaso	40	Failing 1500	—	1,500/2⅞"
Valleyview						
Cascade Drlg Co Ltd	2	dsl	—	Wisn Roadair	—	9,200
	12	dsl	—	Natl 80-B	—	14,000
Duke Drlg Co Ltd	7	dsl	850	Unit U-20	1386	13,500
Lohmann-Johnson Drlg Co Ltd	2	dsl	218	Unit U-15	500	8,500
Valmor						
Commonwealth Drlg Co Ltd	11	dsl	260	Ideco H-40	300	5,500
Virginia Hills						
Regent Drlg Co Ltd	8	dsl	750	Brwstr N-75	780	10,000
Vulcan						
Devon Drlg Co Ltd	1	dsl	700	Emsco GA-500	500	9,500
Wanham						
Trident Drlg Co Ltd	14	dsl	—	"Oilwell" 76	960	10,000
Westward Ho						
Commonwealth Drlg Co Ltd	26	dsl	1275	Natl 80-B	1410	12,000
Pennant Drlg Ltd	6	dsl	1200	Unit U-40	1200	9,500
Whitecourt						
Brown Drlg Ltd	2	dsl	550	Natl 50	550	7,500
Cascade Drlg Co Ltd	5	dsl	—	Natl 50-A	—	7,500
Dominion Drlg Co Ltd	1	dsl	360	Natl T-32	280	5,000
Duke Drlg Co Ltd	9	dsl	500	Unit U-15	650	8,500
Pennant Drlg Ltd	1	dsl	775	Unit U-15	775	8,500
Reading & Bates Drlg Co Ltd	4	dsl	950	Natl 80-B	1050	12,000
Tri-Province Drlg Co Ltd	5	dsl	780	Beth Twstr S-55	520	7,500
Wimborne						
Brinkerhoff Drlg Co Ltd	15	dsl	370	Natl 50-A	450	8,500
Commonwealth Drlg Co Ltd	7	dsl	750	Natl 50	530	6,500
Pennant Drlg Ltd	4	dsl	1000	Crdwll O	650	9,500
Winfield						
Commonwealth Drlg Co Ltd	16	dsl	560	Emsco GB-350	450	6,500
BRITISH COLUMBIA PROVINCE						
Arrow Drlg Co	4	dsl	250	Emsco SB-350	500	7,000
	26	dsl	600	Emsco GB-800	1200	13,000
Can American Drlg Ltd	3	dsl	750	Natl 80-B	1645	10,000
Alcan Highway—Mile 200						
Reading & Bates Drlg Co Ltd	7	dsl	400	Natl 55-A	700	12,500
Blueberry						
Dallas Drlg Co Ltd	1	dsl	578	Emsco GB-500	500	8,000
	2	dsl	578	Emsco GB-500	500	8,000
	3	dsl	500	Emsco GB-350	520	6,500
Boundary Lake						
Commonwealth Drlg Co Ltd	15	dsl	800	Brwstr N-7	600	8,000
Charlie Lake						
Dallas Drlg Co Ltd	4	dsl	500	Emsco GB-250	320	5,000
Dawson Creek						
Reading & Bates Drlg Co Ltd	2	dsl	800	Natl 100	1050	12,000
Ft. Nelson						
Brinkerhoff Drlg Co Ltd	14	dsl	370	Emsco GB-500	600	8,500
Ft. St. John						
Commonwealth Drlg Co Ltd	20	dsl	1040	Ideco 7-11	900	10,500
	22	dsl	750	Natl 50	530	6,500
Devon Drlg Co Ltd	3	dsl	700	Emsco GB-500	500	9,500
	2	dsl	300	Emsco GA-350	350	7,500
Dominion Drlg Co Ltd	5	dsl	800	Emsco G-500	900	9,000
Parker Drlg Co of Canada Ltd	7	dsl	600	Natl 55	670	9,000
	10	dsl	400	Natl 50-A	500	7,000
Pennant Drlg Ltd	3	dsl	600	Crdwll O	540	7,500
Regent Drlg Co Ltd	5	dsl	720	Brwstr N-7	520	8,000
	24	dsl	720	Brwstr N-7	520	8,000
Trident Drlg Co Ltd	6	dsl	—	Emsco 500	640	8,500
Trinity Canadian Drlg Co	1	dsl	995	Emsco GC-500	770	10,000
	3	dsl	720	Emsco 350	670	7,000
	4	dsl	990	Natl 80-B	990	12,000
	7	dsl	875	Emsco GC-500	720	10,000
Mile 125						
Trinity Canadian Drlg Co	5	dsl	1250	Emsco A-800	1150	15,000
Pouce Coupe						
Parker Drlg Co of Canada Ltd	6	dsl	420	"Oilwell" 52-T	420	6,500
MANITOBA PROVINCE						
Cascade Drlg Co Ltd	6	dsl	—	Natl T-20	—	4,500
	11	dsl	—	Crdwll D	—	5,500
	16	dsl	250	Unit U-34	250	4,500
Virden						
Peter Bawden Drlg Ltd	4	dsl	220	Crdwll RL	205	4,500
Commonwealth Drlg Co Ltd	18	dsl	160	Crdwll RL	170	4,500
Coultis Drlg Ltd	1	dsl	238	Ideco H-25-D	235	4,000
	2	dsl	245	Wisn Mogul	245	4,000
	3	dsl	200	Wgnr Mrhse TD2	200	3,500/3½"
Moore Drlg Co Ltd	3	dsl	320	Brwstr N-4	190	4,000
ONTARIO PROVINCE						
Lambton						
Union Rotary Drlrs (Can) Ltd	1	gas-LPG	200	Natl 40	180	4,000
	3	gas-LPG	200	Natl 40	180	4,000
Windsor						
Eakle & Holder Drlg Co	4	dsl	300	Natl T-20	—	5,500
Regent Drlg Co Ltd	21	dsl	260	Brwstr N-4	260	5,500
SASKATCHEWAN PROVINCE						
Peter Bawden Drlg Ltd	3	dsl	270	Crdwll S	180	4,500
Can-Tex Drlg Co Ltd	—	—	—	Lucey ES6	—	5,500
	—	—	—	Crdwll RL	—	5,000
	—	—	—	Crdwll RL	—	5,000
Loffland Bros Co	100	gas	670	—	675	8,000
	138	dsl	670	—	600	9,000
Lohmann-Johnson Drlg Co Inc	5	dsl	300	Crdwll S	440	4,500
Alida						
Commonwealth Drlg Co Ltd	25	dsl	425	Unit U-34D	300	5,500
Bienfait						
General Pet of Canada Ltd	2	dsl	250	Unit U-34	250	4,800
	8	dsl	250	Natl T-25	250	5,000
Carievale						
General Pet of Canada Ltd	12	dsl	250	Natl T-20	250	4,600
Carnduff						
Brinkerhoff Drlg Co Ltd	10	dsl	200	Natl T-32	300	6,000
Commonwealth Drlg Co Ltd	4	dsl	260	Crdwll RL	170	4,500
	13	dsl	390	Emsco GB-350	450	6,500
Reading & Bates Drlg Co Ltd	9	dsl	350	Natl 50-A	450	7,000

Schulz and Schultz know for sure . . .

Why Cost-Conscious Mud Engineers Specify Du Pont CMC

Warren Schulz (left), manager of the New Orleans office of Barada & Page, shows Eddie Schultz, Du Pont Technical Representative, newly replenished stock of the multi-purpose mud additive, Du Pont CMC. Rapidly increasing sales volume is his proof that Du Pont CMC is being specified by more and more mud engineers. To give prompt delivery throughout his area, this office now stocks Du Pont CMC in Baton Rouge, Lake Charles and Mobile, in addition to New Orleans.

And Eddie Schultz (right) can tell you why. He's a mud engineer himself, has trained mud engineers and drilling personnel, and has helped evaluate all types of drilling mud additives. Now, as a Field Representative for Du Pont, he's helped oil producers save substantially per foot in mud costs by using Du Pont CMC. He can show you why it is the best additive on the market to give fluid-loss control at low viscosity *and* at low cost.

If you don't know Schulz or Schultz, why not get acquainted and take advantage of their services and the benefits of Du Pont CMC? Order it from:

- YOUR LOCAL MUD DEALER
- BARADA & PAGE—Corpus Christi, Dallas, Ft. Worth, Houston, New Orleans, Odessa, Oklahoma City, Kansas City, Tulsa, Wichita.
- MACCO CORP., Paramount, Calif.
- DU PONT EXPLOSIVES DEPARTMENT offices in Dallas, Los Angeles, or Wilmington, Del.

DU PONT
REG. U. S. PAT. OFF.

Better Things for Better Living
. . . through Chemistry

DU PONT CMC FOR DRILLING MUDS

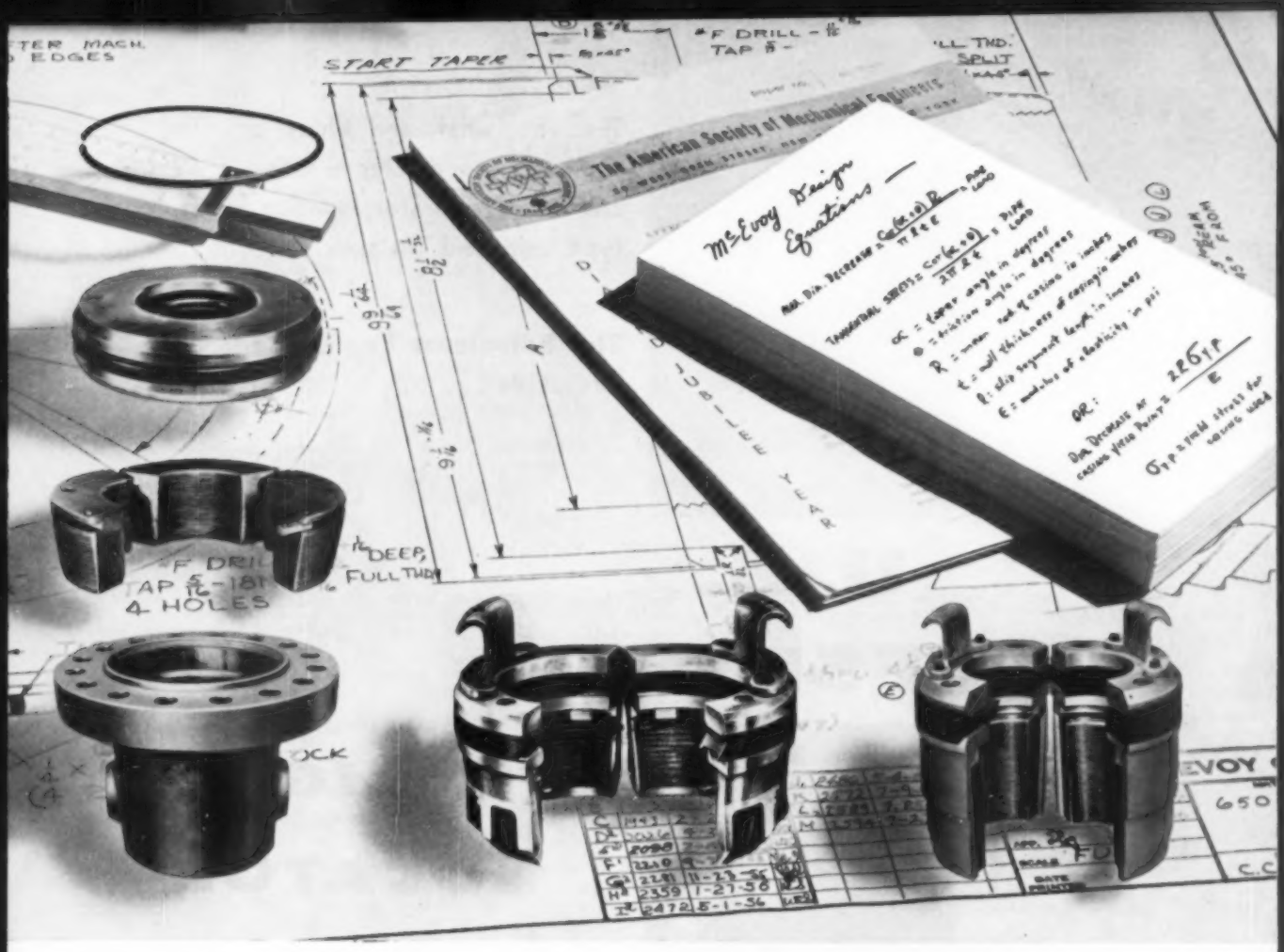
Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
Colville						
Precision Drlg Co Ltd	A	dsl	276	Ideco H-20-D	184	3,500
Estevan						
Brinkerhoff Drlg Co Ltd	12	dsl	200	Natl T-32	300	6,000
General Pet of Canada Ltd	1	dsl	250	Natl 50	525	7,000
Hunter Drlg Ltd	1	dsl	450	Crdwll	260	6,000
	3	dsl	450	Crdwll	260	6,000
Kenyon's Drlg & Serv Ltd	12	dsl	—	Frnks Comet 658	—	5,000
Moore Drlg Co Ltd	4	dsl	330	Emsco 300	300	3,500
Parker Drlg Co of Canada Ltd	5	dsl	420	Natl 50	420	7,000
Regent Drlg Co Ltd	4	dsl	260	Brwstr N-4	260	6,000
	22	dsl	260	Brwstr N-4	260	6,000
	23	dsl	260	Brwstr N-4	260	6,000
	27	dsl	260	Brwstr N-4	260	6,000
	29	dsl	260	Brwstr N-4	260	6,000
Hudsons Bay						
Gustavson Drlg Co Ltd	2	dsl	500	Natl T-32	250	6,200
Kingsford						
Commonwealth Drlg Co Ltd	5	dsl	260	Emsco GB-250	310	5,000
	6	dsl	690	Ideco M-750	600	7,000
Lampman						
Commonwealth Drlg Co Ltd	12	dsl	260	Natl T-32	300	5,500
	14	dsl	430	Ideco H-40	300	5,500
General Pet of Canada Ltd	9	dsl	375	Natl T-25	250	5,500
Manor						
Precision Drlg Co Ltd	1	dsl	276	Ideco H-30-D	276	5,000
Midale						
General Pet of Canada Ltd	19	dsl	435	Crdwll S	175	4,500
Precision Drlg Co Ltd	6	dsl	550	Ideco H-30-D	276	5,000
Prince Albert						
Big Horn Drlg Ltd	2	dsl	250	Crdwll L	180	3,500
Ralph						
Commonwealth Drlg Co Ltd	24	dsl	520	Natl 50	600	6,000
Ratcliffe						
Tri-Province Drlg Co Ltd	3	dsl	1040	Ideco 7-11	880	11,000
Saskatoon						
Can American Drlg Ltd	6	dsl	275	Natl T-12	260	3,000
Shaunavon						
Can American Drlg Ltd	5	dsl	375	Natl T-32	320	5,000
Smiley						
Big Horn Drlg Ltd	3	dsl	300	Crdwll L-350	300	4,500
Steelman						
Double-A Drlg Co Ltd	1	dsl	300	Ideco H-30	265	4,500
Reading & Bates Drlg Co Ltd	1	dsl	300	Natl 50-A	700	7,000
Stoughton						
Can American Drlg Ltd	1	dsl	350	Natl T-32	275	5,000
Swift Current						
Precision Drlg Co Ltd	B	dsl	276	Ideco H-30	276	5,000
	D	dsl	276	Brwstr N-4	276	5,000
	E	dsl	450	Ideco 525	550	7,000
Viewfield						
Double-A Drlg Co Ltd	3	dsl	300	Ideco H-40	265	6,000
Wapella						
Precision Drlg Co Ltd	C	dsl	276	Natl T-20	276	5,000
	8	dsl	276	Ideco 30	276	5,300
Watrous						
Can American Drlg Ltd	4	dsl	260	Natl T-20	260	4,000
Weyburn						
Can American Drlg Ltd	2	dsl	650	Natl T-55	975	7,500
Central Leduc Drlg Co Ltd	1	dsl	500	Natl 50	500	6,500
	2	dsl	400	Crdwll TR-66	400	5,000
Commonwealth Drlg Co Ltd	2	dsl	550	Natl 50	420	6,500
General Pet of Canada Ltd	20	dsl	275	Emsco GB250T	550	5,000
	21	dsl	250	Natl T-20	185	4,000
Hunter Drlg Ltd	2	dsl	275	Crdwll	260	6,000
Yorkton						
Can American Drlg Ltd	7	dsl	260	Natl T-20	260	4,500
QUEBEC PROVINCE						
Nicolet						
Union Rotary Drlrs (Can) Ltd	6	dsl	552	Natl 50	552	8,500

Canadian Cable Tools

Contractor's Name	Rig No.	Type Power	HP of Driving Engine	Top to Bottom Drlg Cap.	Workover and Cleanout Depth Cap.	Rig Make and Model
ALBERTA PROVINCE						
Calgary						
Anderberg & Sons Drlg Ltd	1	gaso	50	1200	2000	Star
	3	gas	50	1500	—	Keystone Spdr
	4	dsl	150	7000	—	B Erie 36-L
Red Deer						
Bennett & Hurst Drlg Co Ltd	—	gas	—	2000	—	Mayhew 2000

SOME CONTRACT RIGS IN FOREIGN SERVICE

Contractor's Name	Rig No.	Type Power	Total HP All Main Mud Pumps	Drawworks Make and Model	Total HP Available to Drwwks	Rated Depth with 4½" Pipe
ALASKA						
Kenai Peninsula						
Coastal Drlg Co	3	dsl	1000	Emsco A-800	1650	13,000
ITALY						
Abruzzo						
Campagnia Industrie Metanifere E Affini (Rome, Italy)	2	dsl	260	Ideco H-30	300	4,500
Romagna						
Compagnia Industrie Metanifere E Affini (Rome, Italy)	1	dsl	900	Ansaldo 2000	600	7,000
MEXICO						
Falcon Dam						
Del Mar Drlg Co	3	gas	690	Natl 75	750	10,500
NICARAGUA						
Puerto Cabezas						
Harvey Drlg Co Inc	2	dsl	1200	Emsco GC-500	900	11,500
NORTH AFRICA						
Libya						
Comdrill International Inc	—	dsl	255	Ideco H-30-D	300	4,500
Delta Drlg Co	1	dsl	1250	Emsco A-800	900	11,000
SICILY						
Barrafranca						
Compagnia Industries Metanifere E Affine (Rome, Italy)	3	dsl	500	Emsco GB-500	500	8,500
Segesta						
Compagnia Industries Metanifere E Affine (Rome, Italy)	4	dsl	900	Emsco 800	900	11,000
TURKEY						
Clyde Hall Drlg Co Inc	8	dsl	600	Beth M-58	600	9,000
VENEZUELA						
(Eastern)						
Perforaciones Delta, C A (Caracas, Venezuela)	1	dsl	260	Ideco H-40-D	400	6,500
	2	dsl	260	Ideco H-40-D	400	6,500
	3	dsl	260	Failing 2066	—	—
	5	stm	1200	Emsco UBLS	1690	15,000
	6	dsl	260	Ideco H-40-D	400	6,500
	7	dsl	260	Ideco H-30-D	300	4,500
	10	dsl	260	Crdwll O	450	7,500
Gulf of Paria						
Perforaciones Delta, C A (Caracas, Venezuela)	12	dsl	1560	Emsco J-1250	1250	15,000
(Western)						
Perforaciones Delta, C A (Caracas, Venezuela)	4	dsl	260	Ideco H-40-D	400	6,500
	9	dsl	1000	Emsco GB-800	900	12,000
Lake Maracaibo						
Perforaciones Delta, C A (Caracas, Venezuela)	8	dsl	600	Emsco G-500	500	8,000
	11	dsl	130	Natl T-12	120	2,500
	13	dsl	1040	Emsco J-1250	1250	15,000
	14	dsl-elec	2000	Emsco ECB	1200	15,000
	15	dsl-elec	2000	Emsco ECB	1200	15,000
	16	dsl-elec	2000	Emsco ECB	1200	15,000



How McEvoy uses "CONTROLLED FRICTION" to prevent casing failures

Engineered into each McEvoy Casing Hanger is the exclusive "Controlled Friction" principle, developed by McEvoy to permit hanging of casing to its full joint coupling strength without damage to the casing. This principle is your assurance of maximum safety and economy.

McEvoy "CF" Casing Hangers securely grip the casing with sharp inner teeth while precision-made outer teeth control the slip bowl friction, automatically limiting downward movement of slips in the bowl. These casing hangers effectively solve the problem of reconciling high load capacity and good initial pipe bite by increasing the friction between slip and bowl as the casing load increases, stopping downward casing travel *before* the casing is damaged by the slips.

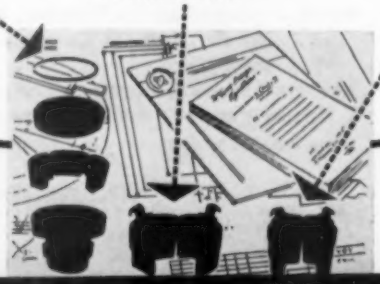
Hydraulic and mechanical loads are completely separated by use of two separate and independent support areas in these McEvoy Hangers. Pipe bottlenecking is completely eliminated and casing pressures, test pressures, or high pressure remedial work cannot load the slips or change their pipe load capacity.

McEvoy casing hangers for all wells

McEVOY "CB" CASING HANGER . . . designed for medium and medium-heavy casing strings . . . combines "Controlled Friction" slips and "Shielded Seal" pack-off with maximum economy . . . will safely hang casing to full short joint coupling strength.

McEVOY "CD-2" CASING HANGER . . . fits the space-saving, low-cost Type "C" Casing Head. Provides economical, medium duty, wrap-around, automatic set and seal service . . . may be wrapped around the pipe and dropped through the preventers to provide automatic sealing with very low pipe load and to safely support the pipe.

McEVOY SD-2 CASING HANGER . . . the complete answer to every deep, high pressure, heavy string need. May be wrapped around the pipe and dropped through the preventers for automatic set and seal . . . will safely support any casing string that can be picked up in the derrick.



McEvoy COMPANY

OIL WELL EQUIPMENT

Texas and Milby Street · P. O. Box 3127

Houston 1, Texas

● *For complete engineering design information on the exclusive McEvoy "Controlled Friction" principle, write for paper, "Effect On Thin-Walled Cylinders of Combined Loading From Tension and External Slip Compression."*

The who, what, and where of U.S. offshore drilling — listing contractor, operator, location, water depth, type unit, and rig specifications

The Petroleum Engineer's exclusive . . .

U. S. OFFSHORE RIG LOCATOR

THE U. S. offshore oil industry has had an uphill battle against the uncertain open waters, fickle weather, and government bickering. In spite of these obstacles, activity and developments offshore have become significant and promise to provide much of the nation's future oil demand.

Drilling in the unprotected waters of the Gulf of Mexico and in the Pacific Ocean off the Coast of California is considerably more complicated than its comparable counterpart ashore. Although major items of drilling equipment have remained the same . . . drawworks, pumps, power compounds, derricks and masts, hoisting system, rotaries, etc., the supporting structure and allied machinery makes the big difference. Drilling equipment is supported by minimum platforms with drilling tenders housing much of the needed facilities; on large self-contained platforms that have everything necessary for operation; on large mobile submersible barges; and on the West Coast, on ships.

Because the offshore drilling operation involves additional types of equipment and structures, the Editors of PE's exclusive RIG LOCATOR felt that it justified a separate and specialized listing.

Some abbreviations. To provide the greatest amount of information in a compact listing, it is necessary to employ some abbreviations. Manufacturer's names are indicated in the introduction of the RIG LOCATOR. Here is a list of abbreviations employed in the offshore section for operators and operator groups:

Operators

Std of Cal — Standard Oil Company of California.

Gen Pet — General Petroleum Corporation.

Std Texas — Standard Oil Company of Texas.

Texaco — The Texas Company.

Ark Fuel — Arkansas Fuel Oil Corporation.

Calif Co — The California Company.

Kermac — Kerr-McGee Oil Industries, Inc.

Pan Am — Pan American Petroleum Corporation.

Phillips — Phillips Petroleum Company.

CATC — Continental Oil Company, The Atlantic Refining Company, Tidewater Oil Company, and Cities Service Oil Company.

CUSS — Continental Oil Company, Union Oil Company of California, Shell Oil Company, and The Superior Oil Company.

M-C-N — Magnolia Petroleum Company, Continental Oil Company and Newmont Oil Company.

Superior — The Superior Oil Company.

CALIFORNIA

Owner's Name, Address	Rig, Barge Name or Number	Operator Drlg For	Offshore Location—(County)	Water Depth Ft.	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
Brown Drlg Co.	—	Monterey-Texaco	Orange, Seal Beach	40	dsl engine	Natl 50-A	750	750	8,000
Humble Oil & Ref. Co.	Rig 52 SM-1	Humble	Santa Barbara	220	dsl engine	Hopper	300	175	3,500
Marex, Inc.	PCS "Exploit"	Texaco	Santa Barbara	110	dsl engine	Howard & Turner	175	175	1,500
	"Labusca"	Western Gulf	Santa Barbara	120	dsl engine	Howard & Turner	165	165	1,500
	"Sandab V"	Tidewater	Santa Barbara	150	dsl engine	Howard & Turner	175	75	1,500
Richfield Oil Corp.	"La Ciencia"		Santa Barbara	140	dsl engine	Hopper Hoist	165	165	1,500
	"Rincon"		Santa Barbara	250	dsl engine	Emsco 160	400	300	4,000
Standard Oil of Calif.	"Western Explorer"	Std. of Calif.	Santa Barbara	220	dsl engine	Hopper Hoist	200	200	3,500
Sun-Marine Drlg. Corp. (Offshore Constr., Inc.)	"Pacific Driller No. 1"	Std. of Calif.	Santa Barbara	80	dsl engine	Natl 110	1500	2500	16,000
General Petroleum Co.	"Torrey"	Gen. Pet.	Santa Barbara	300	dsl egnine	Wagner-Morehouse D15-T 4-B	300	450	4,500
Louis N. Waterfall, Inc.	"Cuss I"	CUSS	Santa Barbara	230	dsl engine	Natl 80-B	2000	2000	8,000

TEXAS

PLATFORM-TENDER DRILLING UNITS

Kerr-McGee Oil Ind.	Bge 16 "Kermac 1"	Std. Texas	Mustang Is. Area	45	dsl egnine	Natl 100	975	975	13,000
Salt Dome Prod. Co.	Rig 10 "Pelican"	Gulf	Mustang Is. Area	55	dsl engine	Beth 1013	1500	1500	28,000

SELF-CONTAINED PLATFORMS

Brewster-Bartle Drlg. Inc.	Rig 3-A	Gulf	Mustang Is. Area Blk 889	50	dsl engine	"Oilwell" 96	1200	1200	12,000
C. G. Glasscock	Rig 1	Ark. Fuel	Mustang Is. Area	39	dsl engine	Natl 130	1200	1520	16,000

LOUISIANA

MOBILE DRILLING BARGES

The California Co.	Rig S-44	Calif. Co.	Main Pass Area Blk 69	16	dsl-elec	—	—	—	—
Coral Drlg Co.	"Mr Arthur"	Callf. Co.	West Delta Area Blk 28	35	dsl-elec	Brwstr NE-12	1250	2500	20,000
Humble Oil & Ref. Co.	Rig 47	Humble	West Delta Area Blk 30	60	dsl engine	—	260	500	5,000
Kerr-McGee Oil Ind.	Rig 40	Kermac	Ship Shoal Area Blk 31	18	dsl engine	Emsco J-1600	1560	1560	16,000
	Rig 44	Kermac-Union	Main Pass Area Blk 47	30	dsl engine	Ideco 1350-S	1700	1700	20,000
	Rig 45	CATC	West Delta Area Blk 84	30	dsl engine	"Oilwell" 96	1560	1560	16,000
	Rig 46	CATC	Vermilion Area Blk 95	58	dsl-elec	Emsco EDA 4-60	1250	2500	20,000
	Rig 47	Shell	Ship Shoal Area Blk 139-A	59	dsl-elec	Emsco EDA 4-60	1250	2500	20,000
Morris & Hamilton	"Carter Mart"	Texaco	S. Timbalier Area Blk 11	40	dsl engine	Wilson 66	2400	2800	25,000
Noble Drlg Co.	S-55	Calif. Co.	Bay Marchand Blk 2	14	dsl-elec	—	—	—	—
Ocean Drlg & Expl.	"Mr Charlie"	Shell	E. Cameron Area Blk 17	40	dsl-elec	Emsco EDA	1500	1000	20,000
	"John Hayward"	Texaco		30	dsl-elec	Emsco ECA	1200	1000	15,000
	"Margaret"	Shell	W. Cameron Area Blk 249	65	dsl-elec	Emsco EDES	1500	1000	20,000
	"St. Louis"	Shell	South Pass Area Blk 27	30	dsl-elec	Emsco ECB	1200	1000	15,000
The Offshore Co.	Rig 53	Humble	Eugene Is. Area Blk 77	26	dsl-elec	Natl 130-E	1860	1860	20,000
	Rig 54	Calif. Co.	Vermilion Area Blk 164	101	dsl-elec	Natl 130-E	2625	2000	20,000
	Rig 55	Calif. Co.	Bay Marchand Blk 23	40	dsl-elec	Natl 130-E	2625	2000	20,000

LOUISIANA (Continued)

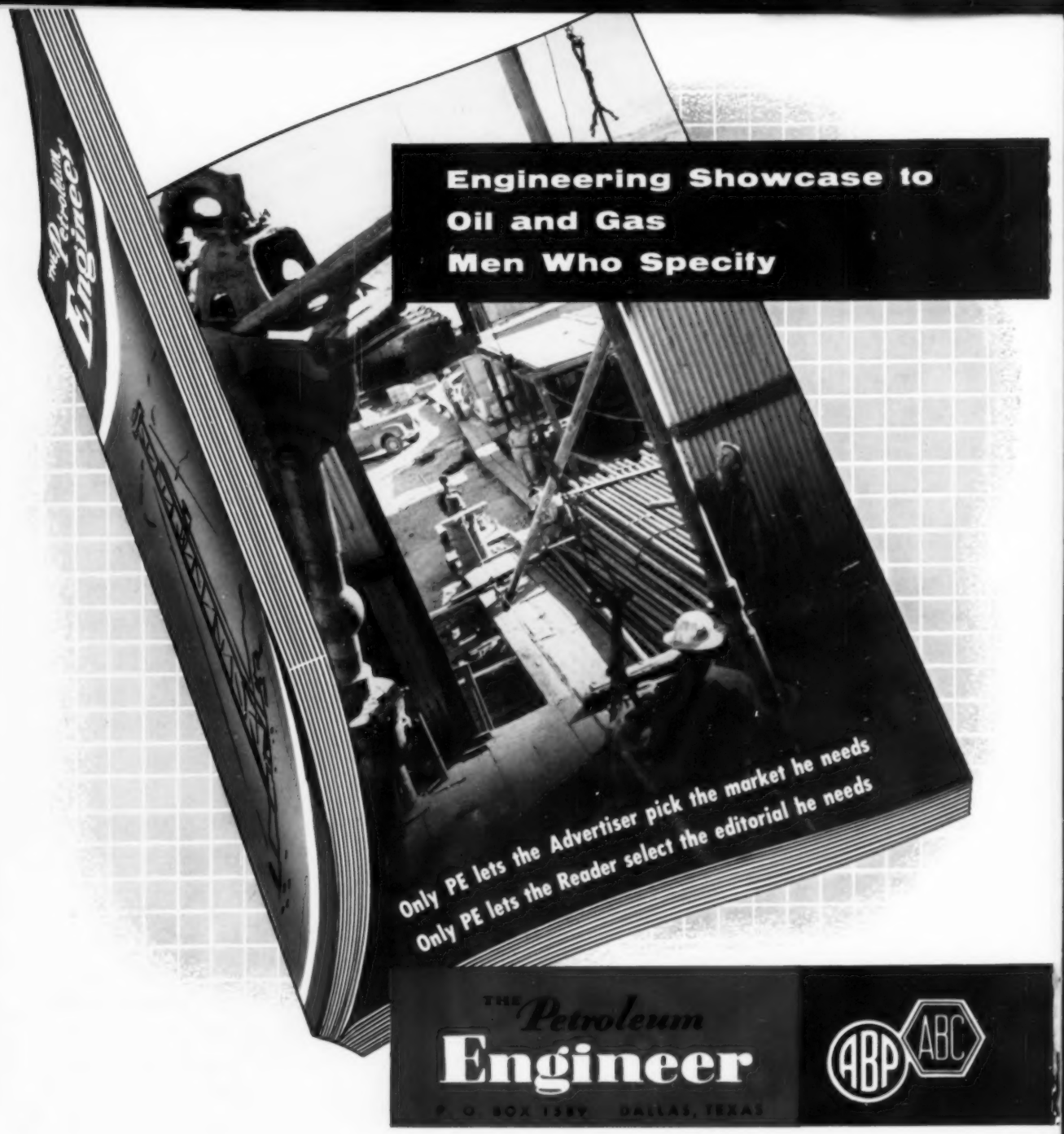
Owner's Name, Address	Rig, Barge Name or Number	Operator Drlg For	Location—Designation	Water Depth Ft.	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
Phillips Pet. Co.	Rig 42	Phillips	Breton Sound Ar.	10	dsl egine	"Oilwell" 76	825	650	12,000
Rowan Drlg. Co., Inc.	Rig 14 "M.G. Rowe"	CATC	West Delta Area Blk 54	—	dsl-elec	Emsco ECA 4-54L	2325	1600	18,000
	Bge 19	Calif. Co.	Bay Marchand Blk 1	18	dsl-elec	U-1220-E	2250	2100	20,000
Shell Oil Co.	Marine Rig 10	Shell	Eugene Is. Area Blk 18	25	dsl engine	Natl 125	1200	1200	12,500
Southeastern Drlg. Corp.	Rig 22-Bge 8	Calif. Co.	Bay Marchand Blk 2	21	dsl engine	Natl	2200	1550	18,000
Zapata Off-Shore Co.	Rig 2 "Scorpion"	Calif. Co.	Main Pass Area Blk 60	62	dsl engine	"Oilwell" 96	2000	2000	18,000
	Rig 3 "Vinegarroon"	Sun	W. Cameron Area Blk 67	35	dsl engine	"Oilwell" 96	2100	2100	18,000

PLATFORM-TENDER DRILLING UNITS

Deepwater Expl Co.	"Deepwater" No. 2	Humble	Grand Isle Area Blk 28	45	dsl-elec	Natl 130-E	1500	1000	16,000
Delta Marine Drlg.	"Joseph Zeppa"	M-C-N	W. Cameron Area Blk 111	42	dsl-elec	Emsco JB-1250	1600	1600	15,000
Dixilyn Drlg Corp.	Rig 6 "Murmanill I"	Gulf	S. Timbalier Area Blk 21	40	dsl engine	Natl 130	1650	2475	17,500
Hawkins-Wilkins Prod. Co.	Rig 2		Eugene Is. Area Blk 77	56	dsl engine	Ideco PR-1050	900	1400	15,000
Humble Oil & Ref. Co.	Rig 36	Humble	West Delta Area Blk 30	60	dsl engine	—	1000	1000	15,000
	Rig 46	Humble	Grand Isle Area Blk 18	60	dsl engine	—	1000	1000	16,000
	Rig 49	Humble	Grand Isle Area Blk 17	60	dsl engine	—	1000	1000	16,000
Kerr-McGee Oil Ind.	Rig 39 & "Frank" Phillips"	Humble	Eugene Is. Area	25	dsl engine	Natl 125	1560	2600	16,000
	Rig 43 & Kermac II	Humble	Grand Isle Area	25	dsl engine	Emsco J-1000	1500	1500	15,000
	Rig 48 & Kermac III	CATC	Vermilion Area Blk 120	68	dsl-elec	Emsco EDA-4-60	1250	2500	20,000
Llano Drlg. Co.	Rig 6 "Clayton G. Dorn"	Forest	Ship Shoal Area Blk 149	55	dsl-engine	"Oilwell" 96	1800	2575	20,000
Loffland Bros.	Rig 127 "R. W. McIlvain"	Pure Group	E. Cameron Area Blk 126	72	dsl engine	Natl 125	1560	1560	15,000
	Rig 130 S-26	Calif. Co.	Bay Marchand Ar.	43	dsl engine	U-30	1200	1800	15,500
	Rig 1 & Rig 148 S-24	Calif. Co.	West Delta Area Blk 29	39	dsl engine	Natl 125	1500	1850	18,000
	Rig 133	Calif. Co.	Main Pass Area Blk 60	62	dsl engine	U-30	1200	1800	15,500
	Rig 149	CATC	S. Timbalier Bay Blk 22 5/2	40	dsl engine	U-1220	1500	1500	20,000
Magnolia Pet. Co.	"Gulf Coast Bge 2"	Magnolia	W. Cameron Area Blk 17	20	dsl-elec	Natl	1250	3500	16,000
Magnolia-Continental-Newmont	Rig 34 Bge 1	M-C-N	Ship Shoal Area Blk 72	25	dsl engine	Natl 125	1040	1040	15,000
	Rig 39 Bge 2	M-C-N	Eugene Is. Area Blk 129	52	dsl engine	Natl 125	1240	1300	15,000
	Rig 44 Bge 5	M-C-N	Vermilion Area Blk 46	20	dsl engine	Emsco JB-1250	1040	1040	15,000
	Rig 45 Bge 6	M-C-N	Eugene Is. Area Blk 125	40	dsl engine	Natl 125	1040	1080	15,000
	Rig 47 Bge 3	M-C-N	Ship Shoal Area Blk 113	52	dsl engine	Natl 125	1040	1040	15,000
	Rig 48 Bge 4	M-C-N	E. Cameron Area Blk 64	50	dsl engine	Emsco JB-1250	1040	1040	16,000
	Rig 57 Bge 7	M-C-N	Eugene Is. Area Blk 94	35	dsl engine	Natl 130	1040	1040	16,000
Nicklos Drlg. Co.	Rig 13 "Ernie Miller"	CATC	West Delta Area Blk 46	39	dsl engine	Natl 125	1400	—	17,000
	Rig 17 "J.C. Craig"	CATC	E. Cameron Area Blk 50	52	dsl engine	Natl 130	1400	—	17,000
Noble Drlg. Co.	— S-21	Calif. Co.	E. Cameron Area Blk 160	84	dsl elec	—	—	—	—
	— S-22	Calif. Co.	Bay Marchand Blk 2	36	dsl-elec	—	—	—	—
	— S-23	Calif. Co.	Bay Marchand Blk 23	18	dsl-elec	—	—	—	—
	— S-24	Calif. Co.	S. Timbalier Area Blk 63	96	dsl-elec	—	—	—	—
Penrod Drlg. Co.	Rig 10 "Eagle"	Gulf	S. Timbalier Bay Blk 128	40	dsl engine	Natl 130	1500	1520	18,000

LOUISIANA (Continued)

Owner's Name, Address	Rig, Barge Name or Number	Operator Drlg For	Location—Designation	Water Depth Ft.	Type Rig Power	Drwwks Make & Model	Total hp Available to Drwwks	Total hp to all Main Mud Pumps	Rated Drlg Depth with 4½" Pipe
Phillips Pet. Co.	Rig 40	Phillips	Bay Marchand Ar. Blk 5	35	dsl engine	Natl 125	1350	1200	16,000
Reading & Bates Offshore Drlg. Co.	"J. W. Bates"	CATC	E. Cameron Area Blk 71	60	dsl engine	Natl 130	2000	3000	20,000
	"George M. Reading"	CATC	Vermilion Area Blk 102	67	dsl engine	Natl 130	2000	3000	20,000+
Rowan Drlg. Co., Inc.	Rig 17	CATC	E. Cameron Area Blk 63	52	dsl engine	Natl 125	1305	2100	15,000
	Rig 30	Humble	Grand Isle Area Blk 18	50	dsl engine	Emsco A-1500	1500		18,000
Southeastern Drlg. Corp.	Rig 12 Bge 9	CATC	West Delta Area Blk 57	—	dsl engine	"Oilwell" 96	1100	2250	16,000
Zapata Off-Shore Co.	"Nola No. 1"	M-C-N	Eugene Is. Area Blk 89	20	dsl engine	Natl 130	1500	2000	15,000
INLAND BARGE — PLATFORM									
Magnolia Pet. Co.	Rig 52 "Gulf Coast Bge 1"	Magnolia	Main Pass Area Blk 46	25	dsl engine	Natl 125	1560	1560	15,000
SELF-CONTAINED PLATFORMS									
Big Chief Drlg. Co.	Rig 34	Phillips	Eugene Is. Area Blk 172	86	dsl-elec	Emsco EDA-4-60	1600	2560	18,000
Brewster-Bartle Drlg. Co.	Rig 1	CATC	W. Delta Area Blk 45	50	dsl engine	"Oilwell" 96	3300	3300	12,000
Dixilyn Drlg Corp.	Rig 7	Gulf	Ship Shoal Area Blk 154	56	dsl engine	Natl 110	2475	2475	20,000
Loffland Bros.	Rig 46	CATC	Grand Isle Area Blk 47	96	dsl-elec	Natl 34-10	2840	1550	20,000
	Rig 62	CATC	Grand Isle Area Blk 47	95	dsl-elec	Natl 34-10	1500	1600	20,000
	Rig 125	Phillips	Eugene Is. Area Blk 129-A	52	dsl-elec	Natl 34-10	1600	1050	20,000
	Rig 144	Shell	Eugene Is. Area Blk 128-A	48	dsl engine	U-30	1500	1500	18,000
Humble Oil & Ref. Co.	Rig 50	Humble	Grand Isle Area Blk 16	—	dsl engine	—	900	450	10,000
Magnolia-Continental-Newmont	Rig 59	M-C-N	Eugene Is. Area Blk 119	38	dsl engine	Natl 55	920	920	7500
Nicklos Drlg. Co.	Rig 19	CATC	Grand Isle Area Blk 69	110	dsl engine	Natl 130	1680	—	17,000
Noble Drlg. Co.	(dual rigs)	Calif. Co.	Bay Marchand Blk 2	20	dsl-elec	—	—	—	—
The Offshore Co.	Rig 7	—	Eugene Is. Area	60	dsl-elec	Natl U-34-10FE	1700	1700	20,500
	Rig 21	—	E. Cameron Area	70	dsl-elec	Natl U-34-10FE	1700	1700	20,000
	Rig 24	Shell	Eugene Is. Area Blk 116	50	dsl-elec	Natl 130-E	1700	1700	20,000
Phillips Pet. Co.	Rig 45	Phillips	Eugene Is. Area Blk 191	85	dsl-elec	Emsco ECC	1250	1250	18,000
The Power Rig Drlg. Co.	Platform No. 9	Magnolia	Eugene Is. Area Blk 89	30	dsl engine	U-15	750	1000	11,000
Rimrock-Tidelands	"Rimrock I"	Sinclair	Eugene Is. Area Blk 175	87	dsl engine	Beth MC950	1200	1200	18,000
	"Rimrock III"	Sinclair	S. Timbalier Area Blk 86	90	dsl-elec	Brwstr N12A	1400	1800	18,000
Rowan Drlg Co., Inc.	Rig 8	Humble	Grand Isle Area Blk 18	50	dsl engine	Natl 125	2340	1920	18,000
	Rig 11	CATC	Grand Isle Area Blk 47	81	dsl engine	U-1220	2400	2250	20,000
Salt Dome Prod. Co.	Rig 12	Gulf	Ship Shoal Area Blk 154	60	dsl engine	Beth Tornado	900	1350	14,000
Shoreline Drlg Co.	Rig 3	CATC	West Delta Area Blk 58	46	dsl engine	U-1220	2400	2400	20,000
	Rig 7	CATC	West Delta Area Blk 59	50	dsl engine	U-1220	2400	2400	20,000
Southeastern Drlg Corp.	Rig 7	M-C-N	Eugene Is. Area Blk 128	52	dsl engine	"Oilwell" 96	1560	1040	14,000
	Rig 23	M-C-N	Eugene Is. Area Blk 126	38	dsl engine	"Oilwell" 96	1560	1560	14,000
	Rig 25	M-C-N	Eugene Is. Area Blk 128	52	dsl engine	Natl 130	1560	1040	16,000
The Superior Oil Co. of Calif.	Rig 20	Superior	W. Cameron Area Blk 72	48	dsl engine	Natl 125	900	900	12,000
	Rig 27	Superior	W. Cameron Area Blk 101	48	dsl engine	Natl 125	900	900	12,500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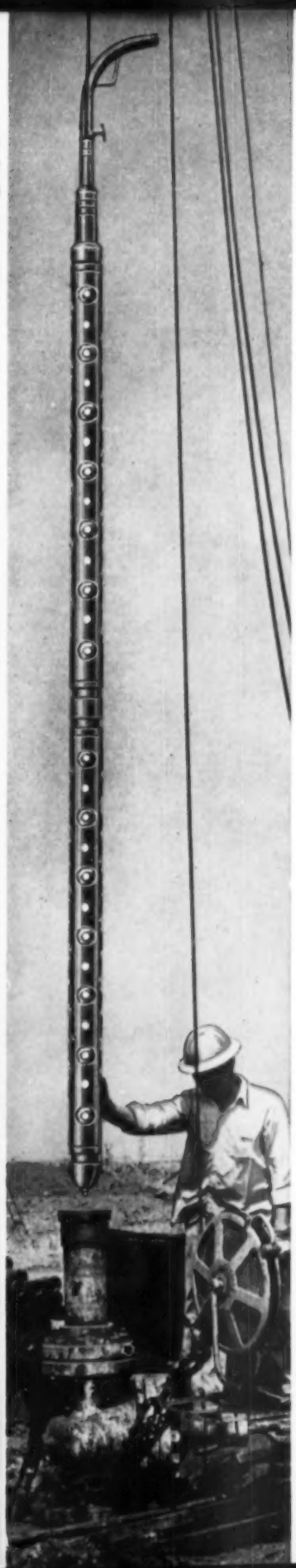

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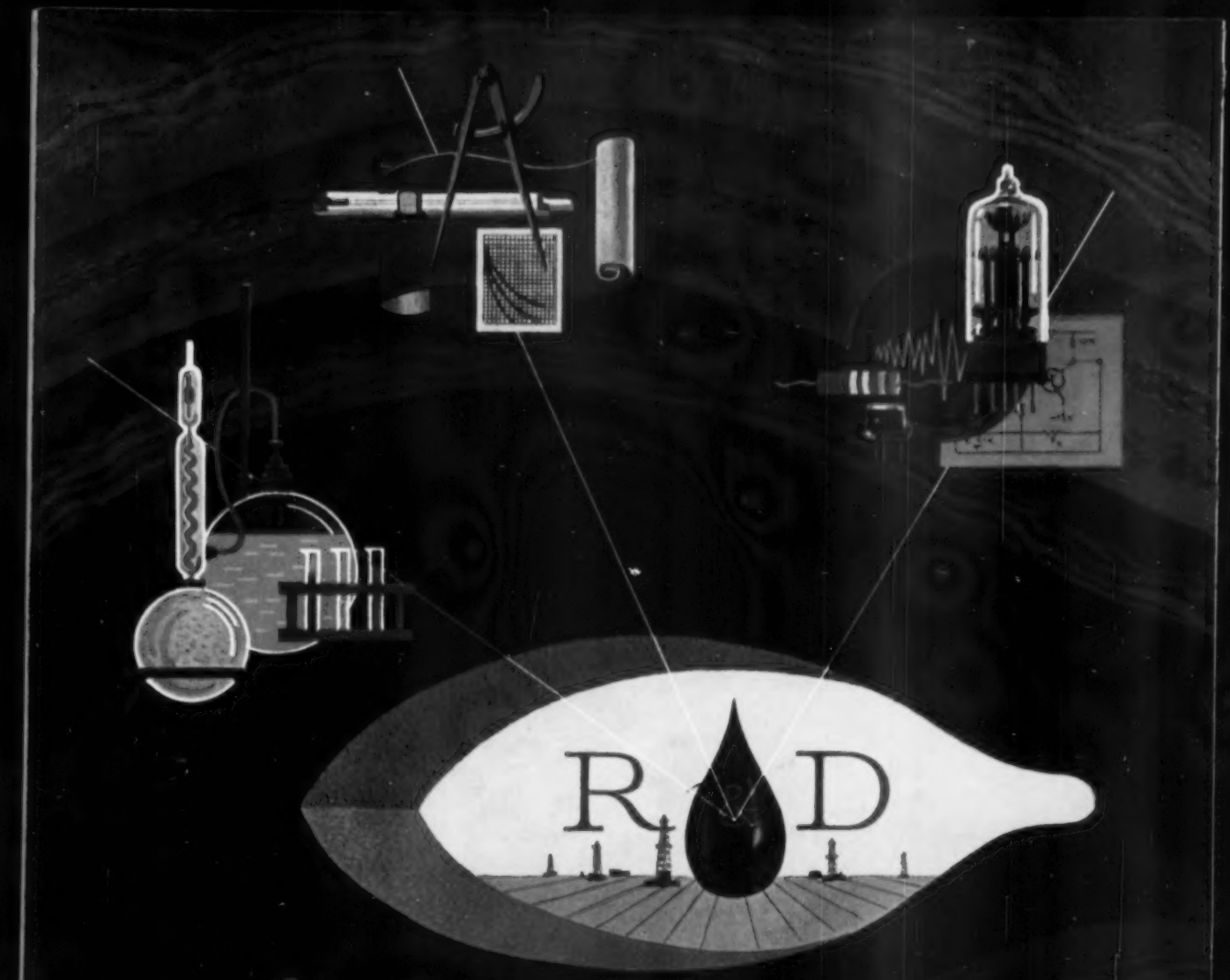

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